The Senate

Foreign Affairs, Defence and Trade References Committee

Planned acquisition of the F-35 Lightning II (Joint Strike Fighter)

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Recommendation 1

6.11 The committee recommends that the Department of Defence develop a hedging strategy to address the risk of a capability gap resulting from further delays to the acquisition of the F-35A. The strategy should be completed by 2018 and capable of implementation by 2019 at the latest.

Recommendation 2

6.19 The committee recommends that the Department of Defence develop a sovereign industrial capability strategy for the F-35A to ensure that Australian aircraft can be maintained and supported without undue reliance on other nations.

Recommendation 3

6.20 The committee recommends that the government endeavour to establish Australia as the Asia-Pacific maintenance and sustainment hub for the F-35.

Chapter 1
Introduction

Referral of inquiry

1.1 On 2 December 2015, the Senate referred the following matter to the Foreign Affairs, Defence and Trade References Committee for inquiry and report by 1 May 2016:

> Planned acquisition of the F-35 Lightning II (Joint Strike Fighter), with particular reference to:
>
> a. the future air defence needs that the aircraft is intended to fulfil;
>
> b. the cost and benefits of the program to Australia, including industrial costs and benefits received and forecast;
>
> c. changes in the acquisition timeline;
>
> d. the performance of the aircraft in testing;
>
> e. potential alternatives to the Joint Strike Fighter; and
>
> f. any other related matters.

Conduct of the inquiry

1.2 On 17 March 2016 the Senate agreed to extend the reporting date for the inquiry to 28 June 2016. On 9 May 2016 the inquiry lapsed with the dissolution of the Senate and the House of representatives for a general election on 2 July 2016. On 13 September 2016 the Senate agreed to re-adopt the inquiry with a reporting date of 13 October 2016.

1.3 The committee advertised the inquiry on its website and wrote to individuals and organisations likely to have an interest in the inquiry and invited them to make written submissions.

1.4 The committee received 57 submissions and 16 supplementary submissions to the inquiry. These submissions are listed at Appendix 1 and are published on the committee's website.

1.5 The committee held one public hearing on 22 March 2016 in Canberra. The witnesses who appeared at the hearing are listed at Appendix 2 and the program and *Hansard* transcript of the hearing are published on the committee's website.

History of the Joint Strike Fighter in Australia

1.6 In 1999, Project AIR 6000 was established to acquire a new air combat capability to replace the Royal Australian Air Force (RAAF) F/A-18A/B fighter aircraft when they reached their life-of-type[1] around 2012-15, and the F-111

1 'Life-of-type' describes how long a particular system or asset will remain operationally functional (in a cost effective way) before it needs to be upgraded or replaced.

strike/reconnaissance aircraft when they reached their life-of-type in 2020.[2] The 2000 Defence White Paper confirmed the government's commitment to consider new air combat capability options stating that '[u]p to 100 new air combat aircraft' would be acquired, with the acquisition phase expected to start in 2006-07 and the 'first aircraft entering service in 2012'.[3]

1.7 In 2002, the US invited close allies, including Australia, to invest in the System Development and Demonstration Phase of its F-35 Program, 'where capability is developed, tested and evaluated resulting in capability expansion over time'. In June 2002, the Australian government 'decided in conjunction with the decision to join the F-35 System Development and Demonstration program, that the F-35A was the preferred aircraft to provide Australia's new air combat capability'. Defence advised that it also 'undertook to monitor other prospective candidates should the F-35 Program not develop as expected'. Defence noted that:

> In making this decision Australia recognised the benefits of standardisation, rationalisation and interoperability associated with a cooperative program to satisfy similar operational requirements more affordably, as well as to provide industrial participation opportunities in global supply chains.[4]

1.8 In 2006, the Australian government considered the first stage (First Pass) for the AIR 6000 Phase 2A/B and agreed to Defence committing to the F-35 Production Sustainment and Follow-On Development Memorandum of Understanding, which provides the framework for ongoing partner engagement and obligations through the life of the F-35 capability following the completion of the System Development and Demonstration phase.[5]

1.9 In November 2009, the Australian government approved AIR 6000 Phase 2A/B Stage One (Second Pass) of the Australian Program to acquire:

- 14 F-35A aircraft and the associated support elements necessary to establish the initial training capability in the US at a cost of A$3.2 billion;
- (at least) a further 58 F-35A aircraft in 2012; and
- an additional 28 aircraft to be considered in the context of the Force Structure Review that informed the new Defence White Paper.[6]

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2 Department of Defence, *Submission 55*, p. 4; David Watt, *The Joint Strike Fighter: overview and status*, Parliamentary Library, 26 July 2012, p. 1.

3 Department of Defence, *Defence new major capital equipment proposals 1998-2003*, 1999, p. 39.

4 Department of Defence, *Submission 55*, p. 4.

5 Department of Defence, *Submission 55*, p. 5.

6 Department of Defence, *Submission 55*, p. 5.

1.10 In March 2010, the US Department of Defense (USDoD) advised that the F-35 Program had breached certain US Government requirements.[7] This, coupled with the impact of the Global Financial Crisis, led to a re-baselining of the F-35 Program, including the deferral of production commitments. Subsequently, the F-35 Program aimed to complete the System Development and Demonstration phase with an initial warfighting capability by the end of 2017. As a consequence, the procurement of the Australian F-35 Program was deferred by two years resulting in initial operational capability moving from 2018 to 2020.[8]

Past parliamentary inquiries

1.11 The Joint Standing Committee on Foreign Affairs, Defence and Trade (JSCFADT) has been monitoring the progress of the Joint Strike Fighter program (JSF program) through its reviews of Defence Annual Reports. The JSCFADT has repeatedly expressed disappointment in the level of transparency and reporting regarding the JSF program.[9] In its most recent review of the Defence annual report, the JSCFADT noted that:

> The information on the Joint Strike Fighter program in the Defence Annual Report and ANAO Major Projects Report is superficial compared to what is reported publically and to the Congress in the United States. In particular, the US Government Accountability Office and DOT&E report to the US Armed Services Committees are far superior to what is reported to the Australian Parliament. Information regarding the Joint Strike Fighter program, such as the allocation of specific weapons to software blocks, is available on various US websites. Defence must be more transparent in their reporting and not hide behind claims of national security classification when the information in readily provided by other countries, in particular the US. As Australia is one of the eight international partner countries in the Joint Strike Fighter program, the Committee emphatically believes that the reporting on the program available to the Australian Parliament be on par with that available to the US Congress.[10]

Performance audits

1.12 In 2013, the Australian National Audit Office (ANAO) conducted companion performance audits regarding the management of Australia's air combat capability, considering the acquisition of the F-35A Joint Strike Fighter and the upgrades and sustainment of the F/A-18 Hornet and Super Hornet. The audits acknowledged that

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7 The Nunn-McCurdy Act requires the US Department of Defense to report to Congress whenever a Major Defense Acquisition Program experiences cost overruns that exceed specified thresholds.

8 Department of Defence, *Submission 55*, p. 5.

9 Joint Standing Committee on Foreign Affairs Defence and Trade, *Review of the Defence Annual Report 2013-14*, p. 48; Joint Standing Committee on Foreign Affairs Defence and Trade, *Review of the Defence Annual Report 2012-13*, p. 68.

10 Joint Standing Committee on Foreign Affairs Defence and Trade, *Review of the Defence Annual Report 2013-14*, p. 48.

there are inherent risks associated with advanced defence technology development and production programs:

> This audit report draws attention to the wide-ranging cost, schedule and performance risks inherent in advanced defence technology development and productions programs such as the JSF Program. These risks arise from the need to:
>
> - 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.[11]

1.13 The ANAO reports did not make any formal recommendations regarding administrative improvements to Defence's management of the ADF's air combat capability, noting that the approach by Australian governments and Defence to-date has been appropriate:

> …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.[12]

1.14 However, the ANAO cautioned that it 'remains challenging' to ensure that the coordination of the 'highly complex and costly procurement' of the F-35A with the 'effective sustainment of the ageing F/A-18A/B fleet' would not result in a 'capability gap'.[13]

Structure of report

1.15 The report is structured as follows:

- Chapter 2 considers Australia's air defence capability needs, its current air defence capability and the air defence capability promised by the F-35A Lightning II Joint Strike Fighter (F-35A);

11 Australian National Audit Office, *Audit report No. 6 (2012-13) Management of Australia's Air Combat Capability—F-35A Joint Strike Fighter Acquisition,* pp 20–21.

12 Australian National Audit Office, *Audit report No. 6 (2012-13) Management of Australia's Air Combat Capability—F-35A Joint Strike Fighter Acquisition,* p. 30.

13 Australian National Audit Office, *Audit report No. 6 (2012-13) Management of Australia's Air Combat Capability—F-35A Joint Strike Fighter Acquisition,* p. 30.

- Chapter 3 discusses the concerns raised in evidence regarding the performance of the F-35 in testing, including the aircraft's manoeuvrability and flight capabilities; stealth capabilities; mission systems; mission data loads and Autonomic Logistics Information System; its escape system; and the performance and accuracy of the Verification Simulator (VSim);
- Chapter 4 considers the F-35A acquisition schedule and the risk of the creation of a capability gap should there be further delays to the acquisition timeline as well as potential alternatives to the F-35A;
- Chapter 5 considers the effect of Australia's participation in the F-35 program on local industry and the Australian economy, including the costs and benefits; and
- Chapter 6 includes the committee's view and recommendations.

Acknowledgements

1.16 The committee thanks all those who contributed to the inquiry by making submissions, providing additional information or appearing at the hearing.

Chapter 2

Australia's air defence needs

Introduction

2.1 This chapter considers Australia's air defence capability needs, its current air defence capability and the air defence capability promised by the F-35A Lightning II Joint Strike Fighter (F-35A).

Defence capability needs

2.2 The 2016 Defence White Paper (White Paper) outlines Australia's defence strategy and its three strategic objectives:

- to deter, deny and defeat any attempt by a hostile country or non-state actor to attack, threaten or coerce Australia;
- to support the security of maritime South East Asia and support the governments of Papua New Guinea, Timor-Leste and Pacific Island Countries to build and strengthen their security; and
- to provide meaningful contributions to global responses to address threats to the rules-based global order which threaten Australia and its interests.[1]

2.3 In order to meet these objectives, the government asserts Australia must 'maintain a regionally superior ADF with the highest levels of military capability and scientific technological sophistication'.[2]

Air defence capabilities

2.4 The value of air power provided by the RAAF is undisputed. It provides air mobility (the ability to move things through the air); intelligence, surveillance and reconnaissance (ISR); strike (the ability to effect things on the ground and sea from the air); and control of the air (the ability to control the air domain to ensure freedom from air attack, freedom to manoeuvre and freedom to attack).[3] Air power provides a task force commander with a greater number of options to address challenges:

> The combination of its speed, reach and responsiveness provide the capability to carry out time-critical precision strikes on fleeting targets of opportunity. In the contemporary conflict scenario this is a coveted capability that could potentially reduce the total expenditure if the target that is neutralised is of sufficiently high strategic importance to the adversary. In expeditionary operations, which are becoming more common amongst the forces of the developed world, airlift capabilities are critical to success. While expenditure per unit load of warfighting materiel and provisions may be high in airlift as compared to surface transportation, the

1 Department of Defence, *2016 Defence White Paper*, pp 17–18.

2 Department of Defence, *2016 Defence White Paper*, p. 18.

3 Sir Richard Williams Foundation, *Submission 17*, p. 4.

> speed, reach and penetration capabilities of airlift that will sustain a surface force far away from home base cannot be quantified in dollar terms. Overall, expeditionary operations are better served by airlift than being supported by surface-based lines of supply for reasons of security and a much higher degree of assurance.[4]

2.5 The White Paper also describes 'a potent strike and air combat capability' as 'essential to our ability to deter attempts to coerce or attack Australia and our national interests, including the ability to seize the initiative, and defeat potential threats as far from Australia as possible'. The White Paper states that Australia 'must be prepared to carry out offensive strike operations against the military bases and in-transit forces of a potential adversary' and that this will be achieved through 'strategic strike capabilities, including air strike and special operations capabilities.[5]

2.6 A number of submissions emphasised the importance of maintaining Australia's regional superiority, particularly in the areas of strike and air combat.[6] Mr Steve Weathers asserted that 'Australia requires an Air Superiority Fighter in order to maintain air dominance in the region'.[7] Mr David Archibald noted that 'air-dominance provided by fighter aircraft is the prerequisite for the operation and survival of the rest of the RAAF's aircraft, and for the rest of Australia's armed forces'.[8] The Australian Strategic Policy Institute (ASPI) noted the importance of strong air combat capability:

> The ability to wield airpower effectively has been firmly established as a prerequisite for success in high-end war fighting. To be sure, there are many things that the ADF can be called on to do that don't require it, but it's a 'must have' if the nation ever faces a significant military threat.[9]

2.7 However, ASPI explained that 'defending Australia is less demanding than attacking defended territories elsewhere'. ASPI noted that air combat threats to Australia's direct interests and territories are likely to remain modest in size for some time to come and, unlike the United States, Australia does not have global power projection ambitions and is unlikely to unilaterally deploy forces in support of global

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4 Sanu Kainikara, *The Art of Airpower: Sun Tzu Revisited*, (Air Power Development Centre, 2012), p. 65.

5 Department of Defence, *2016 Defence White Paper*, pp 94–95.

6 For example: Mr Chris Mills, *Submission 1*, pp 2–3; Mr Michael Price, *Submission 2*, pp 13–14; Dr Jai Galliott, *Submission 3*, p. 1; Mr Danny Nowlan, *Submission 6*, pp 1–6; Mr David Archibald, *Submission 8*, pp 4–9; Air Power Australia, *Submission 9*, pp 1–3; Mr Steve Weathers, *Submission 10*, pp 1–2; Mr John Peake, *Submission 11*, pp 1–5; Mr Marcus Kollakides, *Submission 12*, pp 4, 8–9; Name withheld, *Submission 13*, pp 1–2; Name withheld, *Submission 14*, p. 6; Mr Eric Palmer, *Submission 19*, p. 6; AIRCMDR Ray Perry (Retd), *Submission 22*, pp 2–3; Mr Peter Larard, *Submission 25*, pp 1–2; Mr Gary Bates, *Submission 29*, p. 2; Mr Robert Gottliebsen, *Submission 34*, pp 1–3; and Mr Peter Goon, *Submission 36*, pp 2–8.

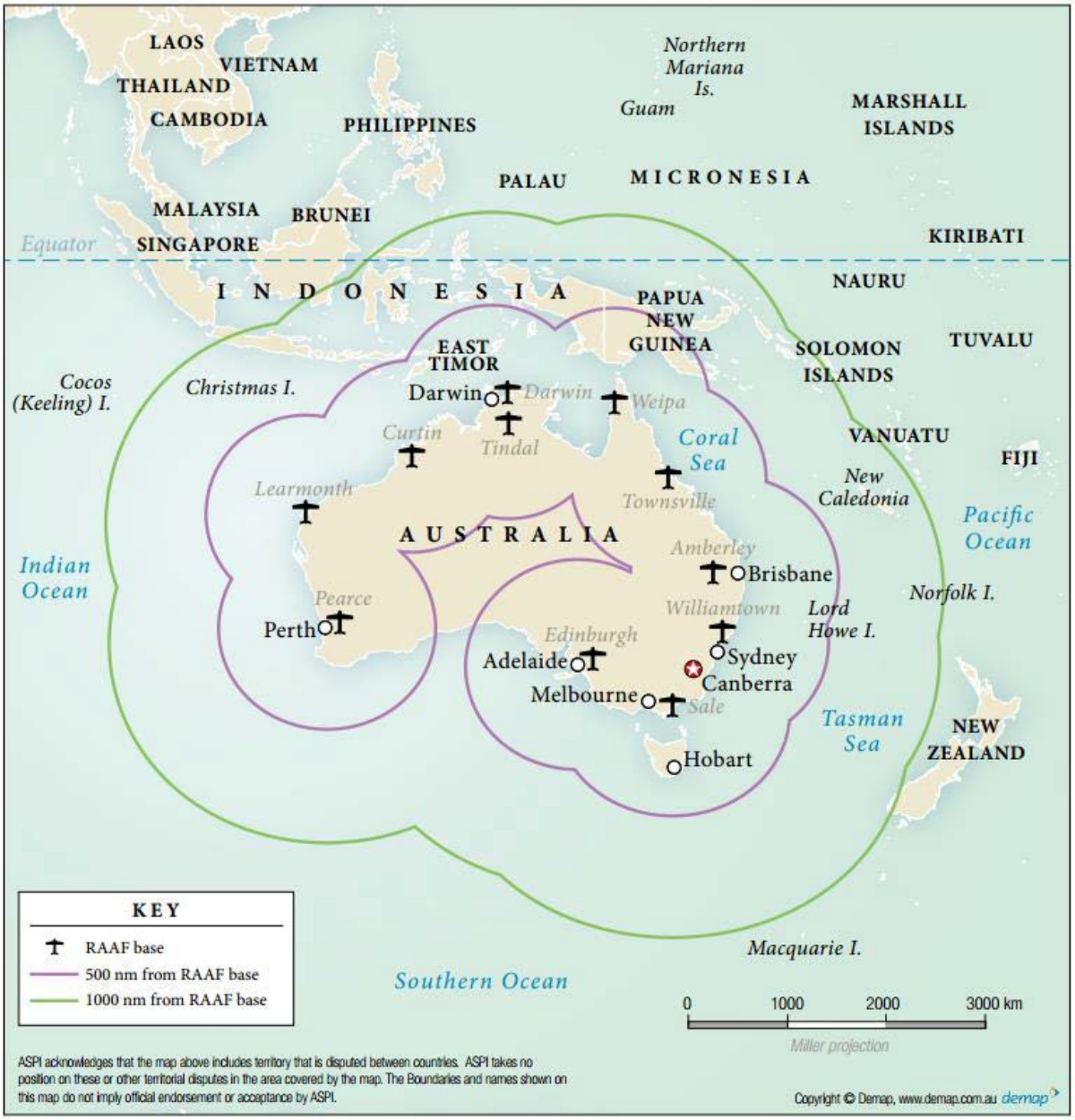
7 Mr Steve Weathers, *Submission 10*, p. 1.

8 Mr David Archibald, *Submission 8*, p. 6.

9 Australian Strategic Policy Institute, *Submission 47*, p. 27.

interests. ASPI advised that 'the single most important task of the RAAF is to raise the costs and risks of threatening Australian territory to any would-be aggressor. A key part of the role of Australia's future air combat capability will be the way it enables or conducts maritime denial operations'.[10]

Figure 2.1—F-35 combat radius with and without single air-to-air refuelling



Source: Australian Strategic Policy Institute, *Submission 47*, p. 32.

10 Australian Strategic Policy Institute, *Submission 47*, pp 30–31.

Current air defence capabilities

2.8 Australia's air combat capability is currently provided by the RAAF fleets of F/A-18 Classic Hornet (air control and strike) and F/A-18F Super Hornet.[11] In 2004, the ASPI report, *A Big Deal: Australia's future air combat capability*, noted that, whilst the RAAF's F/A-18 and F-111 aircraft had provided Australia with potent air combat and strike capabilities over the last two (and now three) decades, 'the cost of keeping both fleets operating has risen substantially while their effectiveness in the twenty-first century regional threat environment has diminished'.[12]

2.9 Defence advised the committee that 'Australia's air combat capability needs have been 'derived through extensive and detailed consideration for a strategic baseline that reflects Government's expectations of the air combat force'. Defence explained that these expectations require an air combat capability that is able to defeat airborne threats, prosecute attacks against both land and sea surface targets, and support Australia's land and maritime forces.[13] The White Paper outlined Defence's acquisition plans to achieve these capabilities:

> The ADF will be equipped with a potent and technologically advanced strike and air combat capability over the next decade, building on the current fleet of 24 F/A-18F Super Hornets, six E-7A Wedgetail Airborne Early Warning and Control aircraft and five KC-30A air-to-air refuelling aircraft. In addition to 12 EA-18G Growler Electronic Attack aircraft which will enter service from 2018, 72 F-35A Lightning II Joint Strike Fighters will begin to enter operational service from 2020 to replace the Classic Hornets. Options to replace the Super Hornets in the late 2020s will be considered in the early 2020s in light of developments in technology and the strategic environment and will be informed by our experience in operating the Joint Strike Fighters. The Government will also acquire new air combat training systems as part of the Key Enablers capability stream.[14]

F-35A Lightning II Joint Strike Fighter

2.10 Defence advised the committee the F-35A is the 'most advanced, affordable multi-role fighter capable of meeting Australia's strategic need for a highly effective air combat capability'. Defence explained that the F-35A will replace the aging F/A-18 A/B Classic Hornets. The F/A-18 A/B will be progressively withdrawn from service between 2018 and 2022, whilst the F-35A will transition into service in Australia from 2019 to 'ensure continuity in Australia's air combat capability'.[15] The Chief of the Air Force, Air Marshal Leo Davies, told the committee that the F-35 is the 'best and only option' for the replacement of the F/A-18 A/B Classic Hornets:

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11 Department of Defence, *Submission 55*, p. 8.

12 Australian Strategic Policy Institute, *A Big Deal: Australia's future air combat capability*, 2004, p. 3.

13 Department of Defence, *Submission 55*, p. 8.

14 Department of Defence, *2016 Defence White Paper*, pp 94–95.

15 Department of Defence, *Submission 55*, p. 8–9.

> Air Force has operated the fighter force and the ability to conduct control of the air pretty much since our inception. We will be retiring our Classic Hornet fleet in the early twenties and we have gone through a process of determining the best replacement aircraft type for the Classic Hornet. In Air Force's view, and in my view, the joint strike fighter represents the best and only option for the replacement of the Classic Hornet.[16]

2.11 Defence assured the committee that the F-35A's ability to satisfy the Government's expectations of the air combat force was 'subject to comprehensive analysis involving the full scope of available tools and techniques conducted over many years, including thousands of simulation runs and a series of human-in-the-loop mission simulator experiments'. Furthermore, Defence noted that 'the best available performance data for both the F-35A and advanced threat systems were employed for these efforts'.[17]

Fifth-generation air combat capability

2.12 Lockheed Martin explained that there are five key elements that define fifth-generation fighters: very low observable (VLO) stealth, fighter performance, sensor fusion, net-centric operations and advanced air-defence environments.[18] When asked to explain the key differences between fourth and fifth generation fighters, Mr Jeff Babione, the Executive Vice President and General Manager of the F-35 Program at Lockheed Martin, emphasised the stealth, network-centric capability and sensor fusion provided by fifth generation fighters, noting that these advantages cannot be simply added to fourth-generation fighters but must be designed from the beginning:

> There are several attributes that define a fifth generation airplane from a Lockheed Martin and a customer perspective. Number one is stealth—its ability to evade enemy radars, in particular. One of its key features in breaking the kill chain that you talked about earlier today. Also, advanced avionics or subsystems for electronic attack and radar. In the case of the F35 we have the electronic optical tracking system and the distributed aperture systems. These are multispectral devices that are not currently on fourth generation airplanes. In fact, this is the only fifth generation airplane that has those built in. In addition you have a network-centric capability. As others have testified today, the F35 is actually a node in a network of fighting, whether it be other F35s, land forces or sea forces. Finally, senor fusion. That is what we think really separates fifth generation from fourth generation. It takes all of those advanced avionics, the ability to interpret its current stealth conditions, integrating that into the battle space environment, automatically detecting targets and providing that information in a fused situation for the pilot. So the pilot does not have to integrate that; the pilot simply has to act on what the aircraft has determined. You cannot make a

16 Air Marshal Leo Davies, Chief of the Air Force, Department of Defence, *Committee Hansard*, 22 March 2016, p. 65.

17 Department of Defence, *Submission 55*, p. 8.

18 Lockheed Martin, *Submission 46*, p. 6.

> fourth generation airplane into a fifth generation airplane. It has to be designed from the very beginning.[19]

2.13 The Chief Executive of Northrop Grumman Australia, Mr Ian Irving, affirmed that 'the F-35 is a fifth generation capability' which 'cannot be compared easily with fourth generation aircraft due to the tremendous advances in sensor capabilities that are equipping the F-35'. Mr Irving asserted that the F-35's ability to acquire and transmit information from the environment to joint forces via networks provides it with 'significant advantage over other aircraft in inventory today'. Mr Irving noted that, combined with the stealth capabilities of the F-35, this 'provides an advanced situational awareness capability that will deliver significant combat advantage to the Royal Australian Air Force'.[20]

Multirole fighter

2.14 Lockheed Martin emphasised the F-35's versatility as a multirole fighter advising that the F-35 combined stealth, fusion, fighter performance and maintainability as well as 'extensive interoperability with legacy systems and networks with international coalitions and other participant countries':

> The F-35 offers the unprecedented ability to rapidly deploy and penetrate enemy battlespace, seize the initiative, and deter an opposing force. Its unique blend of 5th Generation capabilities provides numerous military options in the presence of advanced, integrated enemy air-defence environments.
>
> As the only 5th Generation multirole fighter available on the international market, the F-35 transforms the battlespace. It allows for a shift in doctrine that takes advantage of the full capability of the F-35 Lightening II, from stealthy surveillance to the full spectrum of combat operations – in highly integrated contested air-defence environments. Representing a true quantum leap in fighter capability, the F-35 will ensure the RAAF's asymmetric advantage. [21]

2.15 United States Lieutenant General Christopher Bogdan, Program Executive Officer for the F-35, advised the committee that the F-35 is 'of vital importance to the security of the United States and its allies, including Australia'. Lt General Bogdan asserted that the F-35 will 'close a crucial capability gap' and will strengthen security alliances:

> The F-35 will form the backbone of air combat superiority for decades to come. It will replace the legacy tactical fighter fleets with a dominant, multirole, fifth-generation capability to project and deter potential adversaries. The F-35 will become a linchpin for future coalition operations

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19 Mr Jeff Babione, Executive Vice President and General Manager of F-35 Lightning II Program, Lockheed Martin, *Committee Hansard*, 22 March 2016, p. 51–52.

20 Mr Ian Irving, Chief Executive, Northrop Grumman Australia, *Committee Hansard*, 22 March 2016, p. 39.

21 Lockheed Martin, *Submission 46*, pp 6–7.

> and will help to close a crucial capability gap that will enhance the strength of our security alliances.[22]

2.16 Lockheed Martin extolled the F-35's 'advanced sensors, sensor fusion and data links' which 'provide multi-spectral situation awareness that is shared in real time with other F-35 aircraft'. Lockheed Martin explained that these advanced features 'support cooperative operation and increase flight-group effectiveness and survivability' as well as making 'other ADF assets more effective when they are integrated into combined operational environments in concert with the F-35'.[23]

Plan Jericho

2.17 The White Paper emphasised the importance of investing in and better connecting communications, sensor and targeting systems across ADF platforms.[24] This is reflected in the RAAF Plan Jericho, which aims to 'develop a future force that is agile and adaptive, fully immersed in the information age, and truly joint'. The RAAF asserted that an integrated and networked force will be essential to future capability:

> In the future, responding to global and regional events will be more difficult, as the proliferation of technology and the advancement in potential adversaries' capabilities pose new challenges to the Australian Defence Force…Developing an integrated, networked force will be the difference between simply owning fifth generation aircraft and being a truly fifth generation Air Force.[25]

2.18 The Sir Richard Williams Foundation (SRWF) advised that the focus of air capability has shifted from speed to information, noting that 'information is now the most precious commodity a combat aircraft can provide'.[26] Chairman of the SRWF, Mr Errol McCormack, explained that the integration of systems made possible by the F-35A will change the way the Air Force operates:

> The F35 should not be considered as just another fighter replacing Hornets in service. The F35 will be a communications node capable of sharing information electronically between sections of the force. That fact has already been the catalyst for a change in thinking on development of the Air Force through Plan Jericho. The plan was named after Operation Jericho, which knocked down the walls of a Gestapo prison in France. We are now knocking down the walls between elements of the Air Force as well as the Navy and Army. Each Air Force system—such as airborne early warning and control aircraft, Growler electronic warning systems, or tankers—by itself is very capable, but if used in an integrated system they will change the way the Air Force operates. The ability to share the operational picture

22 Lieutenant General Christopher Bogdan, *Submission 56*, p. 3.

23 Lockheed Martin, *Submission 46*, p. 3–6.

24 Department of Defence, *2016 Defence White Paper*, pp 94–95.

25 Royal Australian Air Force, *Jericho: Program of Work*, 2015, p. 1.

26 Sir Richard Williams Foundation, *Submission 17*, p. 11.

> between systems will ensure that commanders with the best possible information can enable aircraft to engage enemy based on other than their own picture. For example, a Hornet could use an F35-derived picture to engage a target. Development of similar systems on ships and ground-based systems is also underway. Plan Jericho is designed to make people think of using a system of systems when planning acquisition, concepts of operation and training. An integrated Australian Defence Force is greater than the sum of the parts, and acquisition of the F35 has been the catalyst for this change in thinking.[27]

2.19 Lockheed Martin advised that the F-35 is designed to be a 'key net-enabling node in a system of systems, gathering and transmitting data across the defence network'.[28] Lockheed Martin outlined the F-35's role in Plan Jericho, describing the F-35 as 'revolutionary network-enabled capability' that will be 'fundamental to transforming the RAAF into a 5th Generation-enabled force'. Lockheed Martin emphasised the importance of networked capability:

> Future Defence operators will need to deploy and harness the multiplying effect of a contemporary, fully integrated Command, Control, Computers, Communications (C4) Intelligence Surveillance and Reconnaissance (ISR) system. The networked C4ISR system must be capable of delivering outcomes and effects in each of the operating domains, namely: air, land, maritime, cyber and space. Improved C4ISR will provide greater understanding of an evolving operational environment to enable more informed decisions to be made and facilitate efficient and effective directed responses.
>
> With its impressive suite of ISR capabilities, the F-35 will act as a catalyst for achieving that sought-after networked-warfare capability. It permits appropriately protected enabling systems to support the transfer of critical data, from the strategic level through to the tactical edge.[29]

2.20 SRWF expressed its support for Plan Jericho and the F-35A's role in the plan.[30] SRWF noted that fifth generation fighters are an essential part of the defence 'digital ecosystem', which enhances overall capability across various platforms:

> The ADF is well along the path of creating a very capable digital ecosystem both in the air (AEW&C Wedgetail, MQ-4C Triton, P-8A Poseidon, C-17 Globemaster and Gulfstream 550), on the ground (Advanced Field Artillery Tactical Data fire control system, upgrades to ground based air defence and better communications links) and at sea (Anti Ship Missile Defence upgrades, Collins Class upgrades, Air Warfare Destroyer and Landing Helicopter Dock).

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27 Mr Errol McCormack, Chairman, Sir Richard Williams Foundation, *Committee Hansard*, 22 March 2016, p. 14.

28 Lockheed Martin, *Submission 46*, p. 7.

29 Lockheed Martin, *Submission 46*, p. 4.

30 Sir Richard Williams Foundation, *Submission 17*, p. 2.

> What makes the F-22 and F035 special is not just that they have unmatched sensors and stealth, but that they make everyone else in the ecosystem more capable.[31]

2.21 ASPI also emphasised compatibility of systems with allies as an increasingly important element of capability, especially with regards to Australia's involvement in overseas operations:

> …it is the systems that are important. You also have to put it in the context of the sort things that our Air Force actually does…we go and fight in coalition operations with the United States. Having the same equipment that equips many United States squadrons—and I include the Super Hornet in that as well as the F35—we would be on the same footing as the US Air Force and US Navy.[32]

2.22 The committee received a considerable number of submissions questioning the ability of the F-35 to meet Australia's air defence needs. The concerns raised by these submissions and suggestions for potential alternatives are discussed in Chapter 4 of this report.

31 Sir Richard Williams Foundation, *Submission 17*, p. 8.

32 Dr Andrew Davies, Director of Research/Senior Analyst, Australian Strategic Policy Institute, *Committee Hansard*, 22 March 2016, p. 25.

Chapter 3

Performance of aircraft in testing

Introduction

3.1 This chapter discusses the concerns raised in evidence regarding the performance of the F-35 in testing, including the aircraft's:

- manoeuvrability and flight capabilities;
- stealth capabilities;
- mission systems;
- mission data loads and Autonomic Logistics Information System; and
- escape system.

3.2 The chapter also considers concerns regarding the performance and accuracy of the Verification Simulator (VSim).

Classified data

3.3 It is important to note that some submissions emphasised that it is impossible to accurately understand and critique the capabilities of the F-35 without access to detailed classified performance data.[1] The Australian Strategic Policy Institute (ASPI) told the committee that it does not draw on classified information for its public discussion papers and as a result 'have found it difficult to draw confident conclusions one way or the other from publicly available information'.[2] Mr James Hicks cautioned that 'the F-35's effectiveness in air to air combat, air to ground and ship killing roles cannot be evaluated accurately without access to classified information'. Mr Hicks also warned the committee that 'comparisons made of the F-35 with other aircraft are frequently nonsensical'.[3]

Testing and evaluation

3.4 Defence informed the committee that 'the significant capability of the F-35 means the complexity of the test and evaluation process cannot be underestimated'. Defence advised that the test and evaluation (T&E) program is currently employing a 'fly-fix-fly' approach, but warned that while this methodology is appropriate it has 'introduced some schedule risk to the program':

> The F-35 test and evaluation program is currently employing a “fly-fix-fly” approach. While this methodology is appropriate to the complexity of the F-35 software, it has introduced some schedule risk to the program. The US Department of Defense acknowledged this risk in 2014 and curtailed and

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1 For example: Department of Defence, *Submission 55*, p. 26; Australian Strategic Policy Institute, *Submission 47*, p. 2; and Mr James Hicks, *Submission 42*, pp 2, 7–8.

2 Australian Strategic Policy Institute, *Submission 47*, p. 2.

3 Mr James Hicks, *Submission 42*, p. 2.

> rationalised the F-35 test and evaluation program to better focus resources on the testing of the final software to be delivered under the System Development and Demonstration phase in 2017. Notably, in 2015, the program achieved all planned test points, some 1,374 test flights and 9,582 test points.
>
> Given the complexity of the F-35 software it would be unrealistic to assume that problems will not be encountered during test but the measure of a mature program is the ability to effectively prioritise and resolve these issues. The Joint Program Office continues to demonstrate that the safety of the F-35 Program and the delivery of critical warfighting capability to be delivered in the initial software by the end of the System Development and Demonstration phase will not be compromised. Similarly, it is unrealistic to expect complex programs to achieve 100 percent of requirements, but it can reasonably be expected that some lower priority functionality may be deferred to a later phase.[4]

2015 Operational Test and Evaluation Report

3.5 The United States Office of the Secretary of Defense, Director of Operational Test and Evaluation (DOT&E), released the 2015 DOT&E report on the F-35 to Congress on 2 February 2016. Defence advised the committee that the challenges raised in the report 'are well known and being managed by the Joint Program Office, Prime Contractors, and Partner nations' and cautioned that 'the report must be interpreted for the Australian program', noting that:

> The Joint Program Office has acknowledged the schedule risk associated with problems identified during test and evaluation. As reflected in the Director of Operational Test and Evaluation report, most remaining development risk is in software. The Joint Program Office believes that schedule margin exists to develop further software releases, if required, without compromising capability requirements.
>
> Defence believes that this schedule risk is clearly evident and that a delay of between six-12 months to the completion of the System Development and Demonstration phase is likely. Due to the significant gap between the Australian initial operational capability milestone being four years later than the US Air Force initial operational capability (2016) milestone and two years later than the US Navy initial operational capability (2018), Defence assesses that the Australian Program remains on track to achieve initial operational capability in 2020, fully cognisant of the issues raised in the report.[5]

3.6 Defence assured the committee that it is also focused on monitoring other strategic risks, such as 'risks associated with integration of the capability into the Australian environment including the global support solution, maintenance, and pilot training, information systems and the ability to develop mission data files'.[6]

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4 Department of Defence, *Submission 55*, p. 14.

5 Department of Defence, *Submission 55*, p. 16.

6 Department of Defence, *Submission 55*, p. 16.

Manoeuvrability and flight capabilities

3.7 A number of submissions raised concerns regarding the F-35's manoeuvrability and flight capabilities.[7] Mr Peter Goon, Head of Test and Evaluation for Air Power Australia, told the committee that the F-35's flight capabilities do not exceed those of the F-16 and F/A-18 and questioned whether this would adequately serve Australia's future needs:

> …the fundamental problem with the JSF goes to the question: why would you specify your new air combat capability to be comparable with what you have already got? That is what the JSFs have been from day one. You look at the specification, you look at the language of the marketing and the representations made in the formative years of this program; they kept comparing it to a F16 and a F-18. You ask why? That is what you have already got. That is not what is going to be out there in 10, 20, 30 years' time. People were driving along by looking in the rear-vision mirror rather than looking ahead and looking into the future and seeing what the reference threats are going to be—this is the net assessment process referred to earlier—and what you need to do to balance, what you need to do to counter those reference threats so you do maintain balance in global power or, in our case, balance in regional power.[8]

3.8 Mr David Archibald was critical of the F-35's aerodynamic performance, asserting that it is a 'subsonic aircraft in both air intercept and ground attack missions' which cannot achieve supercruise. He advised the committee that the F-35 has very low instantaneous and sustained turn rates, low acceleration, and limited combat endurance:

> The F-35A has combat weight of 18.3 tonnes, a wing loading of 428 kg/m2, thrust-to-weight ratio of 1.07 and span loading of 1.75 tonnes/m. Wing sweep is 34°, and the engine has a power-to-frontal area ratio of 17.9 N/cm2. As a result, the F-35 has very low instantaneous and sustained turn rates (less than half of the F-22's sustained turn rate, or ~11° per second) as well as low acceleration, while its weight harms the transient performance. The F-35's inefficient aerodynamics and inefficient power plant also limits combat endurance despite an excellent fuel fraction of 0.38. The F-35 has a specific fuel consumption of 0.9 lb/lb/hour versus 0.75 for other advanced combat jet engines.[9]

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7 For example: Mr Chris Mills, *Submission 1*, pp 4–10; Mr Daniel Nowlan, *Submission 6*, p. 2; Mr David Archibald, *Submission 8*, pp 14–15, 29–31; Air Power Australia, *Submission 9*, pp 1–3; *Supplementary Submission 9.2*, pp 1–3; Mr Steve Weathers, *Submission 10*, p. 1; Mr John Peake, *Submission 11*, p. 1; Mr Marcus Kollakides, *Submission 12*, p. 6–9; Mr Eric Palmer, *Submission 19*, p. 6; Mr Ted Bushell, *Submission 27*, pp 1–2; Mr Scott Perdue, *Submission 33*, pp 1–3; Mr Peter Goon, *Submission 36*, pp 1–17.

8 Mr Peter Goon, Head of Test and Evaluation, Principal Consultant and Co-Founder, Air Power Australia, *Committee Hansard*, 22 March 2016, pp 5–6.

9 Mr David Archibald, *Submission 8*, pp 14–15.

3.9 However, Mr Hicks cautioned the committee against focusing on manoeuvrability or flight performance when considering the merits of the F-35, noting that the usefulness of manoeuvrability and speed has been drastically reduced since the 1960s. Mr Hicks explained that modern air-to-air missiles are now highly intelligent and have significant advantages over manned fighter aircraft when it comes to speed and manoeuvrability, limiting the ability of any manned aircraft to win a tight manoeuvring 'dog fight':

> Since the 1990s, air to air missiles have become more intelligent and even better equipped. Meanwhile, fighter aircraft have not exceeded their 9-10G maximum emergency manoeuvre – and can't, as they retain a human pilot who would be knocked unconscious by a tighter turn. Obviously missiles have no such limitation.
>
> As a result, the need to out manoeuvre one's opponent has all but vanished from air to air combat, based on statistical analysis of actual air to air kills. Both heat seeking and radar guided missiles now have a kill ratio of over 50% – generally speaking if someone launches a missile at you, most likely you will be shot down by it. Furthermore, the missiles themselves have gotten a whole lot more intelligent, being able to more or less identify "that's a flare, that's chaff, and THIS is my target", as well as plot an intelligent intercept on a manoeuvring target.[10]

3.10 The Sir Richard Williams Foundation (SRWF) argued that the F-35 is highly survivable and lethal when confronting advanced threats. SRWF emphasised that the F-35 was designed as a multi-role aircraft and that its manoeuvrability and flight performance is appropriate for this purpose. It should not be compared to the manoeuvrability and flight performance of high altitude air-to-air combat aircraft such as the F-22:

> The F-35's unequalled situational awareness, combined with advanced weapons and countermeasures, makes the F-35 highly survivable and lethal when confronting advanced threats in the air, land and sea battle space. It is not designed to perform like the F-22, a high altitude air-to-air combat aircraft. It is a multi-role aircraft designed to avoid Within Visual Range operations with acceptable turn performance comparable to the F-15E and F/A-18.[11]

3.11 Defence assured the committee that it is confident in the F-35's manoeuvrability and flight performance. Defence explained that media reports regarding the manoeuvring performance of the F-35 highlight an event which occurred during the conduct of the F-35 test and evaluation during one test flight and have been taken out of context from the larger test and evaluation program.[12] Defence explained that it understands the design parameters for the F-35A and the combined

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10 Mr James Hicks, *Submission 42*, p. 4.

11 Sir Richard Williams Foundation, *Submission 17*, p. 5.

12 Department of Defence, *Submission 55*, p. 15.

effect of its fighter characteristics in the battlespace and is confident that it will meet Australia's needs:

> The F-35 design itself is a product of war fighter requirements which considered the relative importance of specific fighter characteristics in the execution of the intended missions. The importance of stealth, payload, range and combat manoeuvrability, obtained through weapons, fuel and sensors being carried internally, outweighed other potential design choices.
>
> Networked with advanced datalinks and sensors, a combat configured F-35 has the manoeuvrability, stealth and superior situational awareness to enable the engagement of air and surface targets while delaying and defeating the adversary's attack. The above characteristics of lethality, survivability, affordability and supportability define the F-35 as a fifth-generation fighter. Defence understands the design parameters for the F-35A and the combined effect of its fighter characteristics in the battlespace, and is confident that this variant of the F-35 design will meet Australia's war fighting needs.[13]

3.12 Defence noted that Squadron Leader Andrew Jackson, an experienced pilot who has flown both the F/A-18 and the F-35A, found the F-35 to be superior to the F/A-18, stating that 'in [his] experience flying more than 140 hours in the F-35 so far, it is better in performance and manoeuvrability than a representatively configured F/A-18 while remaining easy to fly'.[14]

Stealth capabilities

3.13 A number of submissions raised concerns regarding the F-35's stealth capabilities.[15] Mr Goon questioned the F-35's stealth performance, asserting that the survivability of the F-35 was 'defined around the ability to survive in a battlefield interdiction environment where the aircraft would be confronted by medium range and short range SAMs [Surface-to-Air-Missiles], and AAA [Anti-Aircraft Artillery] systems, assuming that hostile fighters, long range SAMs and supporting radars will have been already destroyed by the F-22 fleet'. Mr Goon asserted that the F-35's stealth performance was 'optimised around this model' but that the evolution of both radars and SAMs have differed from what was anticipated when the Joint Strike Fighter program was launched:

> The JSF's stealth performance, reflected in shaping, was optimised around this model, with independent technical analyses showing that the aircraft

13 Department of Defence, *Submission 55*, pp 4–5.

14 Department of Defence, *Submission 55*, p. 15.

15 For example: Mr Chris Mills, *Supplementary Submission 1.4*, pp 7–13; Mr Michael Price, *Submission 2*, pp 8, 13; Mr Daniel Nowlan, *Submission 6*, pp 1–5, *Supplementary Submission 6.1*, pp 1–4; *Supplementary Submission 6.3*, pp 1–6; Mr David Archibald, *Submission 8*, pp 3, 14, 35–36; Air Power Australia, *Supplementary Submission 9.1*, p. 3, *Supplementary Submission 9.2*, p. 2; Mr John Peake, *Submission 11*, pp 1–4; Mr Marcus Kollakides, *Submission 12*, pp 9–10; Name withheld, *Submission 14*, p. 3; Mr Peter Goon, *Submission 36*, p. 15; Mr Greg Jeanes, *Submission 52*, pp 1–2.

> will have viable stealth in the front sector, but much weaker stealth performance in the beam and aft sectors. The evolving market for radars and surface to air missiles has, however, taken a different turn to that anticipated when the JSF program was launched. Highly mobile long range SAMs, supported by high-power aperture radars, have been far more popular in the market than the short and medium range weapons which the JSF was defined to and built to defeat.[16]

3.14 Mr Daniel Nowlan asserted that the F-35 is not 'all aspect stealth' and that as a consequence, 'any stealth advantage the F-35 enjoys is temporary at best and already compromised'. Mr Nowlan explained that the F-35's inferior stealth capabilities are a consequence of shaping and cannot be changed:

> What is even more critical is that the F-35 is not all aspect stealth. It is only optimised in the forward aspect in the X and Ku Bands. This is a critical oversight because you have no guarantees of where the radar will be in war time. In total contrast the F-22 and B2 were designed with all aspect stealth (the ability to be low observable regardless of the radar location) from the beginning which makes them much more effective because they are much harder to detect. Again this has been known in defence circles for years. Also this is something that can't be fixed. It is a consequence of the shaping of the F-35 and cannot be changed.
>
> What all this means in plain English is that any stealth advantage the F-35 enjoys is temporary at best and is already compromised. A very stark example of this is that Russia has ordered 100 55Zh6ME Nebo M radars. This is a mobile radar that combines VHF, L-band and S-band components with data fusion for counter-stealth. It is also highly likely this radar system will be available for export.[17]

3.15 However, SRWF challenged these assertions, advising the committee that stealth has evolved beyond using radical shaping and exotic materials to give a low radar cross section:

> Stealth is much more than just the traditional view of using radical shaping and exotic materials to give a low radar cross section. True low observability (LO) is designed in from the ground up in every signature of the platform, including IR, RF and the visual spectrums. LO technology also means minimising the probability of intercept of its electronic emissions while at the same time enhancing networking capabilities and situational awareness to give a pilot decision superiority.
>
> Stealth is not about preventing detection; it's about ensuring access. True stealth means that the pilot is able to choose where to operate, when to engage or disengage, and when to be seen or not be seen. It means reducing an adversary's situational awareness to almost zero, thereby providing improved mission success and increased survivability.[18]

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16 Mr Peter Goon, *Submission 36*, p. 15.

17 Mr Daniel Nowlan, *Submission 6*, pp 1–2.

18 Sir Richard Williams Foundation, *Submission 17*, p. 10.

3.16 The Deputy Chairman of SRWF, Mr Geoffrey Brown, asserted that the stealth characteristics of the F-35 and the F-22 are 'not much different', with the only difference being the F-35 stealth coatings are 'far more maintainable than they are on the F-22'.[19] Furthermore, Mr Brown refuted assertions that the F-35 cannot support ground forces effectively, arguing that the F-35's stealth characteristics have been shown to provide effective close air support in contested environments:

> …it was an interesting discussion I had with the Deputy Commandant of Marines. He talked about his legacy aeroplanes which were F-18s, and some of the scenarios they have just run in the last couple of months where they have actually run the F-35 against a high-end surface-to-air missile system—similar to what Senator Fawcett was talking about. They had two F-35s clean and two with weapons, and they were able to do close air support in a very contested environment, which is something they could not do with their legacy aeroplanes. So as far as they are concerned, the capability of the aeroplane is much better for fighting high-end conflict than the F-18 was.
>
> …
>
> Because the stealth characteristics of the F-35 meant that it could actually deal with the high-end SAM, and then they could go in and do close air support with the F-35.
>
> …
>
> That is the normal procedure. Take them out or avoid them, one of the two, and when you are doing close air support you cannot avoid it.[20]

3.17 Dr Andrew Davies, Director of the Defence and Strategy Program at the Australian Strategic Policy Institute (ASPI), advised the committee that the F-35 offers better stealth and electronic warfare capabilities than any other available aircraft.[21] Furthermore, ASPI advised that the F-35 appears to be meeting its stealth design targets:

> …actual testing of the F-35 is indicating that the aircraft is meeting its stealth design targets. Program head Admiral Venlet, in his brief to US media on 21 April, when questioned about the GAO's [United States Government Accountability Office] reference to these issues, said 'in regard to aircraft signature… we have delivered aircraft off the production line and have flown them over ranges and we have very, very good results. We don't have any worries currently that we have detected'.[22]

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19 Mr Geoffrey Brown, Deputy Chairman of the Sir Richard Williams Foundation, *Committee Hansard*, 22 March 2016, p. 18.

20 Mr Geoffrey Brown, Deputy Chairman of the Sir Richard Williams Foundation, *Committee Hansard*, 22 March 2016, p. 19.

21 Dr Andrew Davies, Director of the Defence and Strategy Program, Australian Strategic Policy Institute, *Committee Hansard*, 22 March 2016, p. 20.

22 Australian Strategic Policy Institute, *Submission 47*, p. 17.

3.18 Lockheed Martin described the F-35's stealth capabilities as 'unprecedented in tactical fighter aviation' and stated that its 'integrated airframe design, advanced materials and other features make the F-35 virtually undetectable to enemy radar'. Lockheed Martin advised that 'extensive analysis and flight test of the survivability of the F-35 with its combination of stealth, advanced sensors, data fusion, sophisticated countermeasures, and electronic attack demonstrate conclusively its superior advantages over legacy aircraft'.[23] Mr Gary North, Vice President of Customer Requirements, Aeronautics at Lockheed Martin, assured the committee that they are very confident in the F-35's stealth capabilities:

> I was a user of tactical fast jet airplanes for over 36 years. Lockheed Martin and other companies have been developing stealth for over 40 years. Very low observable stealth is one component of a platform in battle space and the ability to manoeuvre inside the battle space. We are very good at what we do. We know our airplane better than anyone. We model the threats. We are very capable in producing airplanes that are very survivable and very lethal. There have been large assertions of adversary airplanes. They are behind us in capability. Obviously, they believe stealth is very important or they would not be trying so hard to develop it. So we are very confident in the capabilities of the platform.[24]

Mission systems

3.19 The term 'mission systems' refers to the operating software, avionics, integrated electronic sensors, displays, and communications systems that collect and share data with the pilot and other friendly aircraft. Lockheed Martin asserted that the 'F-35 has the most robust communications suite of any fighter aircraft built to date. It will also be the first fighter to possess a satellite-linked communications capability that integrates beyond line-of-sight communications throughout the spectrum of missions it is tasked to perform'.[25] Lockheed Martin advised that the key elements of the mission systems software include:

- **Sensor Fusion**: which enables pilots to draw on information from all of their on-board sensors to create a single integrated picture of the battlefield and automatically share this information with other pilots and command and control operating centres on their network;
- **Active Electronically Scanned Array (AESA) Radar**: which enables pilots to engage air and ground targets at long range, while also providing situational awareness for enhanced survivability;

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23 Lockheed Martin, *F-35 Capabilities: Multi-Mission Capability for Emerging Global Threats*, https://www.f35.com/about/capabilities, accessed 17 August 2016.

24 Mr Gary North, Vice President of Customer Requirements, Aeronautics, Lockheed Martin, *Committee Hansard*, 22 March 2016, p. 64.

25 Lockheed Martin, *F-35 Full Missions Systems Coverage: Mission Systems and Sensor Fusion*, https://www.f35.com/about/capabilities/missionsystems, accessed 17 August 2016.

- **Distributed Aperture System (DAS)**: which provides pilots with 360-degree spherical situational awareness, sending high resolution real-time imagery to the pilot's helmet from six infrared cameras mounted around the aircraft. This allows pilots to see the environment around them and to detect and track approaching aircraft from any angle. The DAS is integrated with other sensors within the aircraft, so if the F-35's radar detects something of interest, DAS's software will analyse it and make the pilot aware of potential threats. When there are multiple threats, the DAS is able to identify the highest value targets and recommend the order in which to deal with each threat. It provides missile detection and tracking; launch point detection; situational awareness infra-red search and track (IRST) and cueing; weapons support; day/night navigation; fire control capability; and precision tracking of friendly aircraft for tactical manoeuvring;
- **Electro-Optical Targeting System (EOTS)**: which combines forward-looking infrared (FLIR) and infrared search and track (IRST) functionality to enhance the pilot's situational awareness and provide precision air-to-air and air-to-surface targeting capabilities;
- **Helmet Mounted Display System**: which provides pilots with 'unprecedented situational awareness' as all the information pilots need to complete their missions—airspeed, heading, altitude, targeting information and warnings—is projected on the helmet's visor, rather than on a traditional Heads-up Display on the canopy widescreen. The DAS streams real-time imagery to the helmet from six infrared cameras mounted around the aircraft, allowing pilots to "look through" the airplane and see the entire environment surrounding them. The helmet also provides pilots with infrared night vision through the use of an integrated camera, making images in total darkness look exactly like they would in daylight; and
- **Communications, Navigation and Identification (CNI) Avionics System**: which provides pilots with the capability of more than 27 avionics functions. The CNI uses software-defined radio technology to allow for simultaneous operation of multiple critical functions, such as identification of friend or foe, precision navigation, and various voice and data communications.[26]

3.20 A number of submissions raised concerns regarding the performance of the F-35's mission systems.[27] Mr Mills noted that the F-35's air combat capabilities are

26 Lockheed Martin, *F-35 Full Missions Systems Coverage: Mission Systems and Sensor Fusion*, https://www.f35.com/about/capabilities/missionsystems, accessed 17 August 2016.

27 For example: Mr Chris Mills, *Supplementary Submission 1.1*, pp 1–2, *Supplementary Submission 1.2*, pp 3, 8–11; Mr Daniel Nowlan, *Submission 6*, p. 3; Mr David Archibald, *Submission 8*, pp 15–16, 36–37; Mr Donald Bacon, *Submission 16*, pp 1–5; Mr Eric Palmer, *Submission 19*, p. 11; Mr Robert Charette, *Submission 28*, pp 1 –3; Mr Steven Jones, *Submission 44*, pp 10–13; Australian Strategic Policy Institute, *Submission 47*, p. 34; Mr Roger Jennings, *Submission 53*, p. 5.

dependent on the proper functioning of the mission systems software and that the mission systems software development 'is said to be the largest project of its type in the world'. This engenders significant risks of failure:

> In software development, increasing the size of the code-base presents an exponentially increasing risk of failure. For example, 'regression testing' must prove that a sub-program for one operational function does not have adverse or unforeseen consequences to other operational subprograms. Synchronising 'real time' computations across a complex multifunction platform such as the JSF aircraft is another substantial risk.[28]

3.21 United States Lieutenant General Christopher Bogdan, the Program Executive Officer for the F-35, acknowledged that there are ongoing issues with the stability of the mission systems software, but assured the committee that the issues are being identified and resolved:

> Our mission systems software--the software that controls the sensors and weapons, and also provides the pilot with battlespace awareness--is a complex, sometimes tricky, and often frustrating part of the program. The current initial Block 3 software is not nearly as stable as it needs to be to support our warfighters. What I mean by this is that about once every four to four-and-a-half hours of flight time the radar or one of the other sensors has to be reset. Our goal is to reduce this phenomenon to less than once every eight hours. In order to ensure that the software demonstrates the needed levels of stability, the government has launched an in-depth look at the software stability—called a Red Team—to help understand the causes and solutions to this problem. I believe that by the May-June time frame of this year we will have this issue resolved.[29]

3.22 Defence advised the committee that there is schedule risk associated with the completion of the test and evaluation program and incorporation of fixes to meet the scheduled completion of the System and Development and Demonstration phase by the end of 2017:

> The F-35 Program is executing the System Development and Demonstration phase through a developmental test and evaluation program, which evaluates the aircraft and supporting systems, leading to acceptance of these systems. There is schedule risk associated with the completion of the test and evaluation program and incorporation of fixes to meet the scheduled completion of the System Development and Demonstration phase by the end of 2017. The completion of test and evaluation is a critical precursor to the conduct of operational test and evaluation, which aims to test these systems in an operationally representative environment.[30]

3.23 Furthermore, the United States Director of Operational Test and Evaluation (DOT&E) 2015 annual report found that 'full block 3F mission systems development

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28 Mr Chris Mills, *Supplementary Submission 1.1*, p. 2.

29 Lieutenant General Christopher Bogdan, *Submission 56*, p. 10.

30 Department of Defence, *Submission 55*, p. 6.

and testing cannot be completed by May 2017, the date reflected in the most recent Program Office schedule', estimating that the program is not likely to finish Block 3F development and flight testing prior to January 2018.[31]

Helmet Mounted Display System

3.24 Some submissions raised concerns regarding the performance of the Helmet Mounted Display System.[32] Defence acknowledged that there have been issues during the development of the system, including:

- Green Glow: in which the minimum brightness of the optic driver in no-light or low-light conditions was too bright for some carrier operations;
- Jitter: in which the displayed symbols are difficult to read because of the movements of the pilot's head due to the buffet effect;
- Aided Night Vision Acuity: in which there was insufficient contrast in low light conditions; and
- Alignment/Optical Targeting Accuracy: in which symbols' alignment accuracy met requirements for Block 2 capabilities but needed to be improved to meet alignment accuracy requirements for Block 3 and up, which are driven by gun strafe capabilities requirements.[33]

3.25 Lieutenant General Bogdan assured the committee that the Gen III helmet has addressed these issues:

> We originally had problems with our helmet; as you recall they were issues knowns as green glow, jitter, swimming, latency, and poor visual acuity. Twelve months after these discoveries, we fielded our new Gen III helmet…which pilots are using today…with no problems.[34]

3.26 Defence agreed, advising the committee that, while the Helmet Mounted Display System is still assessed as a high technical risk, 'current flight test results are indicating that the Helmet Mounted Display System issues are being addressed by manufacturer, Rockwell Collins, and prime contractor, Lockheed Martin'.[35]

3.27 The DOT&E 2015 report also noted that, after developmental testing of the Gen III helmet, 'developmental test pilots reported less jitter, proper alignment, improved ability to set symbology intensity, less latency in imagery projections, and improved performance of the night vision camera'. However, it warned that

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31 United States Director of Operational Test and Evaluation, *F-35 Joint Strike Fighter*, 2015, p. 35–36.

32 For example: Mr Daniel Nowlan, *Submission 6*, p. 3; Mr David Archibald, *Submission 8*, pp 15–16; Australian Strategic Policy Institute, *Submission 47*, p. 34; Mr Roger Jennings, *Submission 53*, p. 5.

33 Department of Defence, *Submission 55*, pp 19–20.

34 Lieutenant General Christopher Bogdan, *Submission 56*, p. 14.

35 Department of Defence, *Submission 55*, p. 30.

'operational testing in realistic conditions and mission task levels, including gun employment, is required to determine if further adjustments are needed'.[36]

Mission data loads and Autonomic Logistics Information System

3.28 The F-35 relies on mission data loads, which comprise compilations of the mission data files needed for the operation of the sensors and other mission systems components. The mission data loads work in conjunction with the system software data load to drive sensor search parameters and to identify and correlate sensor detections of threat radar signals. The loads are produced by the US Reprogramming Laboratory.[37] The Autonomic Logistics Information System (ALIS) transmits the F-35's health and maintenance action information to the appropriate users on a globally-distributed network to technicians worldwide. ALIS receives Health Reporting Codes via a radio frequency downlink while the F-35 is still in flight, which will enable the pre-positioning of parts and qualified maintainers so that when the aircraft lands, downtime is minimized and efficiency is increased.[38]

3.29 Some submissions raised concerns regarding the F-35's reliance on data exchanges.[39] Mr Archibald warned that disruptions to data exchanges could significantly compromise the F-35's effectiveness and noted that aircraft turn-around will be directly linked to the speed with which the necessary data can be downloaded and uploaded:

> All F-35 software laboratories are located within the United States. This has introduced vulnerabilities in the operation and sustainment of the global F-35 fleet that are only beginning to emerge. The biggest risk is that, since the F-35 cannot operate effectively without permanent data exchanges with its software labs and logistic support computers in the United States, any disruption in the two-way flow of information would compromise its effectiveness.
>
> All F-35 aircraft operating across the world will have to update their mission data files and their ALIS profiles before and after every sortie, to ensure that on-board systems are programmed with the latest available operational data and that ALIS is kept permanently informed of each aircraft's technical status and maintenance requirements. ALIS can, and has, prevented aircraft taking off because of an incomplete data file. Currently, downloading the data file from a 1.5 hour flight of the F-35 takes 1.5 hours.

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36 United States Director of Operational Test and Evaluation, *F-35 Joint Strike Fighter*, 2015, p. 36.

37 United States Director of Operational Test and Evaluation, *F-35 Joint Strike Fighter*, 2015, p. 41.

38 Lockheed Martin, *Autonomic Logistics Information System*, http://www.lockheedmartin.com.au/us/products/f35/f35-sustainment/alis.html, accessed 19 August 2016.

39 For example: Mr Chris Mills, *Supplementary Submission 1.2*, pp 3–11; Mr David Archibald, *Submission 8*, pp 36–37; Mr Eric Palmer, *Submission 19*, p. 11; Mr Robert Charette, *Submission 28*, pp 1 –3; Mr Steven Jones, *Submission 44*, pp 10–13.

> It is hoped to get that down to 15 minutes. By comparison, the Gripen E can be re-armed and refuelled after an air-to-air mission in 10 minutes.
>
> The volume of data that must travel to and from the United States is gigantic, and any disruption in Internet traffic could cripple air forces as the F-35 cannot operate unless it is logged into, and cleared by, ALIS. Updating and uploading mission data loads depends on a functioning Internet. That such a major weapon system would rely upon a separate and delicate system is the height of stupidity.[40]

3.30 Mr Robert Charette asserted that the F-35 cannot function without all of its software operating at an extremely high level, describing the F-35's reliance on ALIS as a 'major source of operational risk':

> Software is the heart and soul of the F-35: without it functioning at an extremely high level of reliability, availability and maintainability, the F-35 is no more than a nice aircraft museum piece. This includes both the embedded software found on the aircraft itself, as well as the ALIS system which is tightly coupled in an unprecedented manner to the F-35…If ALIS indicates that an F-35 isn't ready to fly, it takes significant manual effort to override its decision. Further, it is a major source of operational risk: if ALIS doesn't work correctly, it is no exaggeration to state that the aircraft doesn't work, either. From a systems view, the reliability of the F-35 is a combination of both the embedded flight systems' software and the ALIS system, a fact that the F-35 program understandably does not wish to highlight.[41]

3.31 Mr Charette warned that partner countries' reliance on the United States for mission data files is 'an unquantified economic and operational risk':

> One other known risk issue concerns not only all F-35 software is up-to-date among the US and all its partners, but also that all of the operational mission data files will be available in a timely manner. The F-35 program executive again acknowledges this is proving to be a risk that it underestimated. The impact of latency in delivery of F-35 software or data likely will be more severe than currently being estimated. The lack of control of the F-35 updates by its partners is also an unquantified economic and operational risk.[42]

3.32 Defence acknowledged that 'both the aircraft and support system maturity is still developing', but assured the committee that 'these systems continue to mature and improvements are becoming increasingly evident at operational units'.[43] Defence also advised that it is focused on mitigating strategic risks 'including the global support solution, maintenance and pilot training, information systems and the ability to

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40 Mr David Archibald, *Submission 8*, pp 36–37.

41 Mr Robert Charette, *Submission 28*, p. 1.

42 Mr Robert Charette, *Submission 28*, p. 3.

43 Department of Defence, *Submission 55*, p. 9.

develop mission data files'.[44] Air Vice-Marshal Deeble advised the committee that Defence is working to mitigate these risks by developing mission data reprograming capability:

> I am talking about the ability to reprogram it with the information that is required to conduct each mission. We are setting up a collaborative facility with the Canadians and the UK at Eglin Air Force Base…That will be our reprogramming capability for the aircraft. I think it is true to say that reprogramming across the JSF enterprise is evolving as we speak. The ability to get a mission data file into the aircraft that will do everything we need it to do when the aircraft first arrives back here in Australia is a concern. We are working through those risks as we speak—what we are going to get, how good it is going to be and whether it is going to be capable of supporting our operational testing and evaluation. We are currently looking with the US at a range of risk mitigation approaches to address that specific risk.[45]

3.33 Lockheed Martin advised that the development of ALIS 2.0.2 is underway to support the USAF F-35A Initial Operating Capability in 2016 and that full ALIS capability (the ALIS 3.0 series) is scheduled for delivery in 2017:

> The F-35 Lightning II is the first tactical aircraft system with sustainment tools designed in concert with the air vehicle to optimise operations. Initially fielded in 2009, the Autonomic Logistics Information System (ALIS) is maturing along with aircraft capability. The next generation of ALIS, ALIS 2.0, completed installation at all current F-35 operating locations in March 2015. As a result, it has equipped the F-35 enterprise with improvements across all of its fleet-management reporting tools. A subsequent release, ALIS 2.0.1, completed its roll out to all F-35 locations in September 2015. This upgrade included a deployable hardware suite called the Standard Operating Unit version 2. This suite supports operations on carriers, amphibious craft and remote locations. ALIS 2.0.1 supported the USMC Initial Operational Capability (IOC) in July 2015.
>
> Development of ALIS 2.0.2 is underway to support the USAF F-35A Initial Operating Capability in 2016. It includes four major enhancements: an electronic deployment planning tool, a networking feature, parts life-tracking and the integration of engine propulsion management with air vehicle data.
>
> The full ALIS capability - the ALIS 3.0 series - is scheduled for delivery in 2017, in line with the conclusion of the SOD program phase, to support U.S. and partner-nation operations. Currently, a representative simulation of an ALIS squadron kit is located at Lockheed Martin Centennial House in Canberra. This ALIS squadron kit demonstrates the ALIS functions of

44 Department of Defence, *Submission 55*, p. 16.

45 Air Vice-Marshal Chris Deeble (Retd), Program Manager, Joint Strike Fighter, Department of Defence, *Committee Hansard*, 22 March 2016, p. 71.

> maintenance, supply, training and preventive maintenance activities that are typically performed at the aircraft squadron.[46]

Cybersecurity

3.34 Mr Charette advised the committee that there are growing concerns regarding the cybersecurity requirements for the F-35 and its systems. He noted that the scope of the requirements for cybersecurity were originally underestimated and that much of the security is now being implemented into the systems 'after the fact' rather than being designed 'from the beginning':

> …there is now a requirement for greatly enhanced cyber security above that which was planned for when the F-35 and ALIS were first being developed. As the F-35 contractor program team has admitted, this was an 'unforeseen requirement', at least in its scope. While debatable, the fact remains that to implement security into a system after the fact, rather than designing it in from the beginning, is a well-known 'original sin' of any software system development. With the extensive use of commercial-off-the-shelf (COTS) software in ALIS, much without robust cyber security built in from the beginning, is an especially worrying concern.[47]

3.35 Dr Joiner warned the committee that the F-35 and its systems remain vulnerable:

> Finally, there is the cybersecurity testing. The cooperative vulnerability and penetration testing for the actual aircraft—never mind the logistics system—has not been commenced, and there is no assurance that Australia will be part of that testing. Until it does commence, that software, to my mind, remains vulnerable.[48]

3.36 The DOT&E 2015 report noted that the limited cybersecurity testing that was permitted 'revealed significant deficiencies that must be corrected and highlighted the requirement to complete all planned cybersecurity testing'.[49]

Escape system

3.37 Some submissions raised concerns regarding reports of the failure of the escape system to successfully eject a manikin without exceeding the load/stress limits on the manikin.[50] Defence advised the committee that an increased risk of neck injury to light weight pilots during low speed ejection had been identified and subsequently addressed. In August 2015, the US Services restricted F-35 pilots weighing less than 136 pounds (62 kilograms) from operating the aircraft. Defence advised that,

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46 Lockheed Martin, *Submission 46*, pp 10–1.

47 Mr Robert Charette, *Submission 28*, p. 2.

48 Dr Keith Joiner, *Committee Hansard*, 22 March 2016, p. 27.

49 United States Director of Operational Test and Evaluation, *F-35 Joint Strike Fighter*, 2015, p. 39.

50 For example: Mr Chris Mills, *Supplementary Submission 1.2*, pp 5–6; Mr David Archibald, *Submission 8*, p. 56; Mr Donald Bacon, *Submission 16*, p. 1; Mr Ted Bushell, *Submission 27*, pp 1–2; Mr Peter Goon, *Submission 36*, p. 7; Mr Roger Jennings, *Submission 53*, p. 5.

currently, no F-35 pilots, including Australian pilots, are impacted by this restriction. Safe escape risks are also being reduced by installing a switch on the seat for lightweight pilots that will slightly delay parachute deployment and lessen parachute opening forces; designing a lighter helmet; and mounting a head support panel, which is a fabric panel sewn between the parachute risers which will protect the pilot's head from moving backwards during the parachute opening.[51]

Verification Simulator (VSim)

3.38 A number of submissions questioned the accuracy of the Verification Simulator (VSim) used to test the performance of the F-35.[52] Mr Michael Price asserted that VSim, the main simulation built by Lockheed Martin and used by the F-35 project, does not adequately reflect the capabilities of the F-35. Mr Price advised the committee that 'all the JSF project simulation results gathered over the last 10 years or so have no validity at all'.[53] He also questioned the wisdom of allowing Lockheed Martin to construct both the F-35 and the simulator intended to test its performance.[54] Mr Price described the VSim as the world's most expensive multi-player, interactive videogame, asserting that:

> [The simulation results] only represent parts of a virtual F-35 in a virtual world (Lockheed Martin Land) where the laws of physics, advanced threats and systems are ignored and the virtual F-35 has capabilities that do not exist outside of the simulation.
>
> Right now [the simulation] is not only incomplete in terms of contemporary and future threats as well as models for the combat scenarios but also inaccurate for its intended purpose.[55]

3.39 Mr Chris Mills asserted that the VSim has 'not passed essential Verification and Validation tests'[56] and is therefore incapable of accurately assessing the F-35's combat effectiveness in contested environments:

> Without a functional VSim capability, the JSF will not be able to be evaluated for 'combat effectiveness' in contested environments featuring 'Anti-Access/Area Denial' systems, and highly capable and lethal purpose-built air combat fighters such as the Su-35S, the Su-50, Chengdu J-20 and the Shenyang J-31.[57]

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51 Department of Defence, *Submission 55*, p. 18.

52 For example: Mr Chris Mills, *Submission 1*, p. 12; *Supplementary Submission 1*.2 Mr Michael Price, *Submission 2*, pp 1–16; Mr Daniel Nowlan, *Submission 6*, p. 3, *Supplementary Submission 6.1*, p. 4; Air Power Australia, *Supplementary Submission 9.1*, p. 3; Mr Eric Palmer, *Submission 19*, p. 20; Mr Ted Bushell, *Submission 27*, pp 1–2; Mr Robert Gottliebsen, *Submission 34*, Attachment 1, p. 5.

53 Mr Michael Price, *Submission 2*, p. 6.

54 Mr Michael Price, *Submission 2*, p. 11.

55 Mr Michael Price, *Submission 2*, p. 6.

56 Mr Chris Mills, *Submission 1*, p. 12.

57 Mr Chris Mills, *Supplementary Submission 1.2*, p. 5.

3.40 Dr Keith Joiner raised concerns regarding the small percentage of the F-35's capability in the simulation that has been proven:

> …the validation of the simulation model for the JSF aircraft is badly incomplete, lacks leadership and there has been a small percentage of testing. If you look at [the DOT&E report, it] says 10 per cent of the capability of the JSF in that simulation model has actually been proven. That is 90 per cent that has not been proven, so that is a real worry.[58]

3.41 Many submissions and witnesses pointed to the comments made by the United States Director of Operational Test and Evaluation (DOT&E) in its 2013 report, which stated that it was tracking formal risks with regard to VSim, including among other things:

- risks associated with the timeliness of VSim software delivery, completeness with regard to modelled capabilities, and discrepancies between VSim and aircraft software;
- risks associated with the timeliness, completeness and production-representativeness of data from flight testing and other testing used to verify and validate VSim; and
- fundamental risks regarding the ability of VSim to faithfully replicate all aspects of F-35 and threat systems performance.[59]

3.42 Defence explained that 'simulation is key to replicating the threat environments that the F-35 is expected to be employed in', noting that 'the development of a highly accurate simulation environment that can effectively be used to test the F-35 has been challenging and the path forward is currently being determined by the US Department of Defense'.[60] The former manager of the Joint Strike Fighter program, Air Vice-Marshal Chris Deeble (Retd), advised the committee that VSim remains an area of concern:

> The area of VSim is another area of concern. VSim is not just about testing and evaluation. It is also about high-fidelity training in the full-mission aircraft simulators we have. Lockheed Martin have not lost all of the contract. They are still responsible for refining the aircraft model that is fundamental to VSim. The work that has gone to the US Navy is the work associated with the joint synthetic environment—effectively where the threats get represented appropriately. That work is going to the US Navy, but the two have to come back together. We hope to leverage that. While the simulator has high fidelity for the conduct of ab initio training, you need to train your pilot well in a simulator before you take them into the aircraft. We are concerned about being able to do mission rehearsal, which requires much higher fidelity. We hope to leverage the work that is being done in

58 Dr Keith Joiner, *Committee Hansard*, 22 March 2016, p. 27.

59 United States Director of Operational Test and Evaluation, *F-35 Joint Strike Fighter*, 2012, p. 37.

60 Department of Defence, *Submission 55*, pp 14–15.

> that joint synthetic environment and the work being done at Lockheed Martin to refine their aircraft model—to get that back into the full mission simulator to improve the level and nature of training we can conduct.[61]

3.43 The committee asked Lockheed Martin to explain the basis for its claims regarding the F-35's operational capability if its modelling has not been verified or certified, particularly with regards to threats for ground-based integrated air defence systems, emerging multimode systems, and the emerging Russian and Chinese threats in a stealth-on-stealth situation. Mr Jeff Babione, Executive Vice President and General Manager of the F-35 Lightning II Program at Lockheed Martin, advised that it is currently relying on data from the flight test community:

> Most of that is based on the data from the flight test programs, so not the operational users testing it—although we do have an OT community that has been doing operational tests and evaluation on their own as they get the capability. The scenarios that I am talking about are ones that we have set up as part of the flight test program in the development phase, where we may set up a scenario where we are going against ground forces and we have to detect, track and destroy that target—for example, complete the kill chain, avoid a SAM site as we are approaching or to measure the actual detection range for the SAM site or the ability of the F-35 to avoid it. All that is information or data that is being gathered as we do the flight test program.
>
> The verification and validation that we talk about in the virtual simulation is an extension of that that has yet to actually occur, but we are looking at the data that we are currently seeing from the flight test community as to the capabilities of the aeroplane. The US Air Force and the US Marine Corps have seen that same data and is making decisions as to whether or not the capabilities are sufficient for their IOCs.[62]

3.44 At the time of the 2015 DOT&E Report, these risks do not appear to have been adequately addressed, with the report noting that 'the program has failed to develop and deliver a Verification Simulator (VSim) for use either by the developmental test team or the JSF Operational Test Team'. The report explained that the Joint Strike Fighter Operational Test Team (JOTT) now plan to conduct a significant number of additional open-air flights during Initial Operational Test and Evaluation (IOT&E) to partially compensate for the lack of a simulator test venue:

> The Program Office's sudden decision in August 2015 to move the VSim to a Naval Air Systems Command (NAVAIR)-proposed, government-led Joint Simulation Environment (JSE), will not result in a simulation with the required capabilities and fidelity in time for F-35 IOT&E. Without a high-fidelity simulation, the F-35 IOT&E will not be able to test the F-35's full capabilities against the full range of required threats and scenarios.

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61 Air Vice-Marshal Chris Deeble (Retd), Program Manager, Joint Strike Fighter, Department of Defence, *Committee Hansard*, 22 March 2016, p. 71.

62 Mr Jeff Babione, Executive Vice President and General Manager of the F-35 Lightning II Program, Lockheed Martin, *Committee Hansard*, 22 March 2016, p. 57.

> Nonetheless, because aircraft continue to be produced in substantial quantities (all of which will require some level of modifications and retrofits before being used in combat), the IOT&E must be conducted without further delay to evaluate F-35 combat effectiveness under the most realistic conditions that can be obtained. Therefore, to partially compensate for the lack of a simulator test venue, the JOTT will now plan to conduct a significant number of additional open-air flights during IOT&E relative to the previous test designs. In the unlikely event a simulator test venue is available, the additional flights would not be flown.[63]

63 United States Director of Operational Test and Evaluation, *F-35 Joint Strike Fighter*, 2015, p. 37.

Chapter 4

Acquisition timeline and potential alternatives

Introduction

4.1 This chapter considers the F-35A acquisition schedule, the risk of the creation of a capability gap should there be further delays to the acquisition timeline, and potential alternatives to the F-35A.

Acquisition schedule

4.2 Defence advised the committee that the 'F-35 Program schedule is structured to address the resources required to deliver a highly technical and complex program' and that, as a result, the System Development and Demonstration phase is 'characterised by a concurrent design and production model'. Defence explained that 'this level of concurrency has introduced some risk' to the Program, demonstrated by the Program re-baselining and issues that have become evident during test and evaluation. [1] Defence noted that software development is 'effectively complete' and is now the 'main focus of the ongoing test and evaluation program'. Defence advised that, as at January 2016, the final software build had completed 50 per cent of baseline test points, but that 'significant test points are yet to be undertaken and issues found will need to be rectified'.[2]

4.3 Defence advised that the F-35 Program schedule has 'stabilised' since the re-baselining in 2012, with 'any movements being managed through schedule margins built into the Program'. However, 'completion of the test and evaluation program and ensuring the required warfighting capability at the completion of the System Development and Demonstration phase carries schedule risk that will need to be carefully managed by the Joint Program Office'. Defence assured the committee that it is 'closely monitoring test point achievement and software maturity' and has 'built in additional schedule margin to manage this risk' to ensure that Australian initial operating capacity is met in 2020.[3]

4.4 Defence acknowledged that the re-baselining of the F-35 Program has deferred the procurement of the Australian F-35A by two years, resulting in initial operational capacity moving from 2018 to 2020.[4] Australia plans to ferry the first two F-35 aircraft to Australia in late 2018, with initial operational capability planned for 2020 with the establishment of 3 Squadron (3SQN) to be followed by 2 Operational Conversion Unit (2OCU) and supporting systems and infrastructure at RAAF Base Williamtown. Final operational capability is planned for 2023 with the establishment

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1 Department of Defence, *Submission 55*, p. 13.

2 Department of Defence, *Submission 55*, p. 13.

3 Department of Defence, *Submission 55*, p. 13.

4 Department of Defence, *Submission 55*, p. 13.

of 77SQN at RAAF Base Williamtown and 75SQN at RAAF Base Tindal.[5] Australia's F-35A delivery profile of a total of 72 aircraft is as follows:

- 2 aircraft in 2014;
- 8 aircraft in 2018;
- 8 aircraft in 2019;
- 15 aircraft in 2020;
- 15 aircraft in 2021;
- 15 aircraft in 2022; and
- 9 aircraft in 2023.[6]

4.5 The first two aircraft delivered in 2014 are currently operating as part of the pool of aircraft at the F-35 International Pilot Centre at Luke Air Force Base, Arizona. The next eight Australian aircraft will be delivered in 2018. Six of these aircraft will be based at Luke Air Force Base to facilitate ongoing F-35 pilot training and two aircraft will be ferried to Australia and based at RAAF Base Williamtown. There is a detailed plan to phase the transition of aircraft to Australia from 2019-23. All aircraft will be based in Australia from 2023.[7]

4.6 Defence told the committee that the arrival of the first two aircraft at the end of 2018 is 'a key milestone prior to Australia's initial operating capability' but that 'the schedule for establishing the required support to meet this timeframe is challenging'. Nonetheless, Defence assured the committee that its 'confidence in achieving initial operational capacity is reinforced by the achievement of key milestones'. Of note is the initial operational capacity (IOC) for the first squadron of F-35B (STOVL variant), which was achieved by the US Marine Corps in July 2015.[8]

4.7 On 2 August 2016, General Herbert 'Hawk' Carlisle, the commander of the United States Air Force Air Combat Command, announced that the F-35A has achieved initial operational capacity (IOC) and that the first squadron of F-35As is 'combat ready'. This means the United States Air Force can now send its first operational F-35A squadron (the 34th Fighter Squadron, located at Hill Air Base in Utah) into combat operations.[9] The Chief of Staff of the United States Airforce, General David L. Goldfein, stated that:

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5 Department of Defence, *Submission 55*, p. 5.

6 Department of Defence, *Submission 55*, p. 14.

7 Department of Defence, email responding to request for clarification from Secretariat, (received 21 March 2016).

8 Department of Defence, Submission 55, p. 13.

9 United States Air Force, 'AF declares the F-35A 'combat ready", *Media release*, 2 August 2016, http://www.af.mil/News/ArticleDisplay/tabid/223/Article/885496/af-declares-the-f-35a-combat-ready.aspx, accessed 22 August 2016.

> The combat ready F-35A is the latest fifth-generation fighter aircraft in the Air Force's inventory and provides our nation air dominance in any environment. The F-35A brings an unprecedented combination of lethality, survivability, and adaptability to joint and combined operations, and is ready to deploy and strike well-defended targets anywhere on Earth…Today's declaration of IOC is an important milestone on the road to achieving full warfighting capability for the F-35A.[10]

Capability gap

4.8 The Sir Richard Williams Foundation (SRWF) noted that the Royal Australian Air Force (RAAF) fleet of F/A-18A/B aircraft were delivered in 1985, with a notional life of 6,000 flying hours. The SRWF advised that some of the fleet have already passed this milestone, through careful management of fatigue accrual and a series of upgrades to the airframe. However, as the airframes continue to age, the additional work and costs required to maintain air-worthiness beyond the planned life of the aircraft will increase exponentially, whilst the capability will decrease as more modern threats represent higher risks to the aircraft:

> To give some idea of the magnitude of the additional work required to maintain air-worthiness beyond its planned life, the annual cost of supporting the fleet has doubled in the last five years. Costs would be expected to continue to increase at an accelerating rate as the airframes age further. The airframe/engine maintenance program is designed to have an airworthy fleet of F/A-18 A/B Hornets until 2021/22. By the end of 2022, the majority of F/A-18 A/B Hornets will have reached the end of their useful fatigue life.
>
> Defence has also conducted a mid-life upgrade to most of the avionics on the F/A-18 A/B aircraft. The upgrade closed the capability gap somewhat between Hornet and Super Hornet aircraft. However, by about 2025, the fleet – both Hornets and Super Hornets - would be able to operate in relatively benign airspace only. Operations in airspace contested with either modern air-to-air or ground-to-air threats would represent a high risk.[11]

4.9 The Australian Strategic Policy Institute (ASPI) asserted that Defence should prepare a hedging strategy that provides for the possibility of further delays to the F-35 delivery. ASPI explained that a failure to do so could 'drastically limit the range of possible responses in the early 2020s, and a capability gap could become a possibility'.[12] ASPI noted the wisdom of past hedging strategies:

> It seems to us that it would be prudent to at least devote some staff work to developing an alternative. The RAAF can be expected to resist that notion, as was the case back in 2007 before the Howard government took the

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10 United States Air Force, 'AF declares the F-35A 'combat ready'', *Media release*, 2 August 2016, http://www.af.mil/News/ArticleDisplay/tabid/223/Article/885496/af-declares-the-f-35a-combat-ready.aspx, accessed 22 August 2016.

11 Sir Richard Williams Foundation, *Submission 17*, pp 4–5.

12 Australian Strategic Policy Institute, *Submission 47*, p. 1.

> decision to acquire 24 Super Hornets. The then Chief of Air Force told Parliament that Air Force's view was that purchase of a bridging fighter would only be a last resort. Time has shown that assessment to be wrong, and the Super Hornets now represent a successful hedge against the realised delays in delivery of the F-35.[13]

4.10 ASPI acknowledged that life extension work on the classic Hornet fleet has extended its retirement date from 2015 to 2022 and beyond, but noted that by 2023 the classic Hornets will be well into their fourth decade of service (see table 4.1). ASPI stated that 'there must be some uncertainty in the actual end of life', and that 'given the increasing challenge of keeping a 1980s platform at contemporary standards of capability, scope for further extension would be limited'.[14]

Table 4.1—Current and projected ages of Australia's F/A-18A/B fleet

Year	Number (2016)	Age (2016)	Age (2023)
1985	6 (1xA; 5xB)	31	38
1986	12 (12xA)	30	37
1987	14 (7xA; 7xB)	29	36
1988	24 (20xA; 4xB)	28	35
1989	11 (11xA)	27	34
1990	4 (4xA)	26	33

Source: Australian Strategic Policy Institute, *Submission 47*, p. 4.

4.11 ASPI advised that the 'most sensible hedge' would be to order another tranche of F/A-18F Super Hornets. ASPI explained that this would be the best option as no other fifth-generation aircraft is available on the world market; most, if not all, of the fixed costs of acquiring the Super Hornet have already been borne; and any other type of aircraft would bring with it new supply chains and flight and ground crew training requirements, putting strain on the RAAF's capacity to absorb the several other new types of aircraft in the pipeline. ASPI noted that, taking into consideration a three or more year lead time for the delivery of a new-build Super Hornet, a decision would need to be made by 2019 at the latest.[15]

4.12 The Chief of the Air Force, Air Marshal Leo Davies, assured the committee that he is confident that delays in the development of the F-35 would not result in a capability gap:

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13 Australian Strategic Policy Institute, *Submission 47*, p. 4.

14 Australian Strategic Policy Institute, *Submission 47*, p. 4.

15 Australian Strategic Policy Institute, *Submission 47*, pp 4–5.

> **CHAIR:** Is there a risk that delays in the development of the F-35 could leave Australia with a capability gap? Is there a risk of that at all given the time lines you have mentioned?
>
> **Air Marshal Davies:** Not in my view. We have two pilots and we have two more under training at Luke Air Force Base. Their appreciation of an aircraft that is immature given the context of the aeroplane we will receive at initial operating capability time line gives me considerable confidence that the aeroplane, right now, has significant advantages in its operations over the F-18. As we build over the next four years, my level of confidence remains high.[16]

Alternative aircraft

4.13 A number of submitters expressed concerns that the F-35A would not adequately meet Australia's air defence needs. These concerns primarily focused on the F-35A's flight performance qualities, air combat capabilities, and ability to maintain regional air superiority.[17] In light of these alleged deficiencies, a number of alternative aircraft were raised in evidence.

F-22 Raptor

4.14 The majority of submissions which argued against the procurement of the F-35A asserted that Australia should acquire the F-22 Raptor.[18] Air Power Australia (APA) was highly critical of the F-35A, which it described as 'structurally obsolete'.[19] APA asserted that the F-35A is not capable of meeting Australia's air combat capability needs, warning that 'advances in both Russian and Chinese aircraft, air-to-air missiles, cruise missiles, and smart bombs now challenge the primacy of Western

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16 *Committee Hansard*, 22 March 2016, p. 66.

17 For example: Mr Chris Mills, *Submission 1*, pp 1–3, *Supplementary Submission 1.1*, pp 1–2, *Supplementary Submission 1.3*, pp 1–2; *Supplementary Submission 1.4*, pp 1–3; Mr Michael Price, *Submission 2*, pp 12–16; Mr Anthony Wilkinson, *Submission 4*, pp 1–2; Mr Daniel Nowlan, *Submission 6*, pp 1–6; Air Power Australia, *Submission 9*, pp 1–3; Supplementary *Submission 9.1*, pp 1–2; Mr Steve Weathers, *Submission 10*, pp 1–2; Mr Marcus Kollakides, *Supplementary Submission 12.3*, pp 1–7; Name withheld, *Submission 14*, pp 4–6; Mr Eric Palmer, *Submission 19*, p. 6; AIRCDRE Ray Perry (Retd), *Submission 22*, pp 1–5; Mr Peter Larard, *Submission 25*, p. 1; AIRCDRE Ted Bushell AM (Retd) and AVM B J Graf AO (Retd), *Submission 27*, pp 1–3; Mr Scott Perdue, *Submission 33*, p. 2; Mr Robert Gottliebsen, *Submission 34*, Attachment 1, pp 1 –8; Mr Peter Goon, *Submission 36*, pp 2–5; Mr Geoffrey de Looze, *Submission 38*, p. 2; Mr John Donahoo, *Submission 51*, pp 1–3; Mr Roger Jennings, *Submission 53*, pp 1–4; Mr Erik Peacock, *Submission 54*, p. 2.

18 For example: Mr Chris Mills, *Submission 1*, pp 1–3, *Supplementary Submission 1.1*, pp 1–2, *Supplementary Submission 1.3*, pp 1–2; *Supplementary Submission 1.4*, pp 1–3; Mr Michael Price, *Submission 2*, pp 12–16; Mr Anthony Wilkinson, *Submission 4*, pp 1–2; Mr Daniel Nowlan, *Submission 6*, pp 1–6; Air Power Australia, *Supplementary Submission 9.2*, pp. 1–3; Mr Steve Weathers, *Submission 10*, pp 1–2; Mr Marcus Kollakides, *Supplementary Submission 12.3*, pp 1–7; Name withheld, *Submission 14*, pp 4–6; Mr Eric Palmer, *Submission 19*, p. 6; AIRCDRE Ray Perry (Retd), *Submission 22*, pp 4–5; Mr Robert Gottliebsen, *Submission 34*, Attachment 1, pp 1 –8; Mr Peter Goon, *Submission 36*, pp 1–17.

19 Air Power Australia, *Supplementary Submission 9.2*, p. 3.

air power, believed unbeatable since the Cold War'.[20] APA adamantly asserted that the F-22 Raptor is the 'only alternative' and called for the United States to abandon the F-35 program in favour of restarting production of the F-22.[21] Mr Chris Mills, a member of APA, advised the committee that:

> Without the F-22, the JSF fleet is irrelevant and will be defeated by lethal purpose designed air combat fighters now entering our region. Looking beyond air combat, the joint strike fighter cannot do close air support as well as the purpose-designed battle-proven A10 Warthog is currently doing in the Middle East. You cannot fly safety in contested airspace as the purpose-designed F-22 is doing today over Syria. Other countries will not commit their aircraft in Syria unless they have the protection of the F-22. I can provide proof it cannot survive a destruction of enemy air defence attack against modern SAMs. The JSF cannot control airspace contested with lethal, purpose-designed air combats like the Su-35, now being deployed in our region, and against the coming advanced design like the Sukhoi T-50 and the coming Chengdu J-20.[22]

ZOCT Table

4.15 APA summarised its analysis of the F-35A in its Zero-One Comparative Technique table (ZOCT Table), listed at Appendix 4, comparing the F-35A to the F-22 Raptor, T-50 PAK-FA, Chengdu J-20, Su-35S, and F/A-18F Super Hornet. APA's analysis concluded that:

> In terms of Fifth (5^{th}) Generation Air Combat Fighter Capability Metrics, the F-35A JSF scores poorly, rating only slightly ahead of the F/A-18F Super Hornet—a Gen 4.5 design—yet well behind the Su-35S—the Russian Gen 4++ design.[23]

4.16 The committee questioned APA regarding its confidence in the accuracy of its data and conclusions, noting that the information necessary to accurately assess the capability of the F-35A is highly classified, as is information regarding current generation Russian and Chinese developmental aircraft. APA, however, assured the committee that it is confident in its ability to accurately analyse the capability of aircraft without access to classified information about aircraft capabilities:

> **CHAIR**: I am a bit unclear here. Are you saying you can assess Russian and Chinese aircraft despite the fact that they were trying to keep all of those things secret? Are you saying that you have the wherewithal to just go in there and tell us with definitive facts what a Chinese or Russian stealth fighter can do?

20 Air Power Australia, *Submission 9*, p. 2.

21 Air Power Australia, *Supplementary Submission 9.2*, pp 1–3.

22 Mr Chris Mills, Member, Air Power Australia, *Committee Hansard*, 22 March 2016, p. 1.

23 Air Power Australia, *Supplementary Submission 9.2*, p. 8.

> **Mr Goon**: Within the limits of the analysis, yes. That is what you are supposed to do when you do the net assessments and start the capability development process.[24]

4.17 The committee sought comment from a range of other witnesses regarding APA's ZOCT Table analysis. Dr Andrew Davies, the Director of the Defence and Strategy program at the Australian Strategic Policy Institute, advised the committee that APA's ZOCT Table is 'not a useful contribution to a discussion of the efficacy of the F-35 aircraft'. Dr Davies highlighted a number of flaws in the analysis and methodology of the ZOCT table, noting that:

> The list of characteristics (APA incorrectly calls these 'metrics') of what constitutes a 5th generation aircraft (a term that is not well-defined in any case) is selective and omits or grossly simplifies several of the characteristics that are the strong points of the F-35. Some of the characteristics that *are* included are of debatable value. In particular, the table has several entries that score for high levels of aerodynamic performance—which was never a design goal of the F-35 and is of questionable value in a beyond-visual-range encounter—a key design concept for the F-35.[25]

4.18 SRWF was similarly critical of APA's information, analysis and conclusions, noting that 'to the layman the arguments presented by APA are very persuasive…However, the vast majority of APA's arguments are based on bogus analysis and conclusions'. SRWF advised the committee that APA's ZOCT Table 'is not recognised by anyone else as a basis for assessing 5th generation capabilities' and is 'fundamentally flawed and its conclusion is completely wrong':

> The table focuses excessively on flight performance qualities of 4th and 5th generation fighters. Over half the table relates to the relative flying qualities of the assessed aircraft. Even using these characteristics, a true comparison is only possible with access to classified data. For example, the table is factually incorrect with the data on flight characteristics presented on the F-35 and Super Hornet. The performance of the Russian and Chinese aircraft is also misrepresented. However, even without access to classified data, open source reporting by the Indian Air Force on the deficiencies of the PAK50 give a good indication on the level of misrepresentation inherent in the table. There are videos available on the internet that point to the inadequate performance of both the J20 and J31. Chinese engine technology is many years behind their western equivalents.
>
> The ZOCT Table places significantly less emphasis on the 5th generation characteristics of Very Low Observability (VLO), sensor fusion and network interoperability, which are fundamental to the successful attainment of air superiority in a hostile contested environment. The table significantly underestimates the VLO of the F-35 and significantly

24 *Committee Hansard*, 22 March 2016, p. 6.

25 Australian Strategic Policy Institute, answer to question on notice, 22 March 2016, (received 22 March 2016).

> overstates the Low Observability (LO) capabilities of the PAK50 and J20. Even open source reporting from Russia does not claim the same level of LO that APA states in the ZOCT Table. Another area where APA has significantly understated the F-35 and Super Hornet is in the performance of Active Electronically Scanned Array radars of each aircraft. The underlying data used by APA in their analysis of the competing radars is in error by a very significant margin and that leads to erroneous conclusions about the performance of the respective radars.[26]

4.19 Lockheed Martin advised the committee that APA's ZOCT Table is 'not a relevant assessment' of fifth-generation fighters. It identified three key flaws, noting that the ZOCT Table does not accurately focus on the key discriminators that distinguish the differences between 4th and 5th generation fighters; the ZOCT Table's scoring method incorrectly applies equal weighting to all metrics; and APA's analysis is based on arbitrary and subjective parameters which are reliant on opinion and open source information.[27]

4.20 Defence described APA's ZOCT Table as 'simplistic' advising the committee it 'has not been informed by a comprehensive analysis program and is unsuited to conveying an assessment of capability' and 'contains assumptions and inaccuracies that further detract from its utility':

> The ZOCT is a simplistic aircraft attribute scoring table that is unsuited to convey how individual platform characteristics interact in an operational context to deliver capability outcomes. Further, the ZOCT is unsuited for identifying whether those aircraft, as part of a larger force structure, can meet Australia's strategic requirements. Resolving this question requires useful capability assessments.[28]

Impracticality of acquiring the F-22

4.21 A number of submissions emphasised the impracticality of APA's calls for Australia to acquire the F-22,[29] given that the sale of the F-22 aircraft 'to any foreign government' is prohibited by the United States Congress.[30] ASPI observed that 'there is essentially no chance of the F-22 Raptor being reinstated to production, especially for export'.[31] Defence advised that, even if it was possible for Australia to acquire the

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26 Sir Richard Williams Foundation, answer to question on notice, 22 March 2016, (received 14 April 2016), p. 1.

27 Lockheed Martin, answer to question on notice, 22 March 2016, (received 18 April 2016), p. 132.

28 Department of Defence, answer to question on notice, 22 March 2016, (received 26 April 2016), p. 2.

29 For example: Sir Richard Williams Foundation, *Submission 17*, p. 5; Mr James Hicks, *Submission 42*, p. 8; Australia Strategic Policy Institute, *Submission 47*, p. 4; Department of Defence, *Submission 55*, p. 8; Mr Errol Coultis, *Submission 57*, p. 2.

30 United States Congress, Amendment to the *Department of Defense Appropriations Act 1998*, H.Amdt. 295, 105th Congress (1997-1998).

31 Australia Strategic Policy Institute, *Submission 47*, p. 4.

F-22, its capabilities do not meet Australia's multi-role requirements, due to its limited air-to-surface capability.[32] The SRWF outlined the major impediments to acquiring the F-22, noting that, even if production was reinstated and the ban on exports was lifted, the delivery schedule and costs would be prohibitive:

> Some commentators have proposed reopening the F-22 production line as an alternative to the F-35. There are three key impediments to this presenting a feasible alternative to the F-35. Firstly, the US manufactured the F-22 under Congressional rules that the aircraft would never be exported. Secondly, even if export was feasible, the delivery schedule and costs would be prohibitive for a small production run noting the capability gaps that would emerge through both the planned withdrawal date of the F/A-18 A/B Hornet fleet and broader 5th generation integrated capability systems demands of the future force. Thirdly, and most significantly, the US has proposed developing a replacement for the F-22 in the 2030 timeframe. As such, Australia would run the risk of introducing a capability just as the parent Air Force was ramping down operations and sustainment.[33]

4.22 Mr Errol Coultis noted that the 'F-22A is effectively beyond our reach, regardless of how worthy a contender it might be', explaining that 'we are legislatively prohibited from attempting to purchase the F-22A and we are physically prohibited from attempting to purchase the F-22A by the fact that it is not and is unlikely to ever again be in production'. Mr Coultis warned the committee that, considering these circumstances, calls to acquire the F-22 are 'at best fanciful' and 'at worst deliberately disingenuous and misleading':

> Any support for the acquisition of the F-22A as circumstances stand therefore, in my humble opinion, is not a serious consideration of a solution that will acceptably meet our needs and I respectfully submit that these calls therefore should be treated by the inquiry accordingly.[34]

JAS-39E Gripen, Eurofighter Typhoon and Dassault Rafale

4.23 Some submissions asserted that Australia should purchase the JAS-39E Gripen manufactured by SAAB in Sweden instead of the F-35.[35] One submitter argued that the Gripen would be more cost effective, whilst still providing the necessary multi-role capability. The submitter acknowledged that the Gripen may not have the stealth capabilities of fifth-generation aircraft, but asserted that it nonetheless 'out-performs the F-35A in almost every arena':

> …the JAS-39E Gripen manufactured by SAAB in Sweden provides not only incredible capabilities as a multirole fighter, but even when

32 Department of Defence, *Submission 55*, p. 8.

33 Sir Richard Williams Foundation, *Submission 17*, p. 5.

34 Mr Errol Coultis, *Submission 57*, p. 3.

35 For example: Mr David Archibald, *Submission 8*, pp 3–4; Mr Marcus Kollakides, *Submission 12*, pp 13–15; Name withheld, *Submission 13*, pp 1–2; Mr Geoffrey de Looze, *Submission 38*, p. 2.

> considering its through-life support and maintenance, becomes obvious as a far more cost-effective solution which would provide the RAAF with the means to maintain air superiority as well as supporting other ADF combat elements during armed conflict both in our region and abroad in support of our global interests or as part of a coalition force.
>
> While it may not have the stealth capabilities of 5th generation aircraft such as the F-35, the Gripen has many other attributes such as higher speed (up to Mach 2 I understand, as opposed to 1.6 for the F-35A), better manoeuvrability due to its canard-delta wing configuration, the ability to carry a greater weapons payload for sustained fighting, and perhaps most importantly, a better range and combat radius, able to be extended even further through aerial refuelling with our fleet of KC-30A MRTT aircraft. As a complete package, it out-performs the F-35A in almost every arena, and would give our forces one of the best platforms with which to fight and win against the newest generations of Sukhoi, Mikoyan and various Chinese-built fighters which have been talked about already.[36]

4.24 Mr David Archibald advised the committee that the Gripen would be even more effective than the F-22, asserting that it is the next most capable fighter aircraft and considerably cheaper. Mr Archibald noted that its low operating cost allows for the training of highly proficient pilots, which further increases its effectiveness in combat:

> While the Gripen E is almost as capable as the F-22, its build cost is one quarter that of the F-22 and its operating cost is one tenth that of the F-22. The latter attribute means that countries operating the Gripen E can train their pilots to a much higher level of proficiency than F-22 pilots. In combat, that would result in the Gripen E being more effective than the F-22.[37]

4.25 Some submissions mentioned the Eurofighter Typhoon and Dassault Rafale as potential alternatives to the F-35.[38] Mr Marcus Kollakides noted that 'the Eurofighter Typhoon is probably the world leading dogfighter and air superiority fighter, possibly just inferior to the F-22 Raptor'. Mr Kollakides described the Dassault Rafale as 'a brilliant dogfighter, so close to the Typhoon in ability it is difficult to call'. Mr Kollakides also noted the Dassault Rafale's multi-role capabilities: 'it has exceptional strength and design features which lend themselves to multi role capabilities above and beyond the Gripen or Typhoon' and 'would meet or exceed all the requirements for Australia'.[39]

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36 Name withheld, *Submission 13*, pp 1–2.

37 Mr David Archibald, *Submission 8*, pp 3–4.

38 For example: Mr Marcus Kollakides, *Submission 12*, pp 13–14; Mr Errol Coultis, *Submission 57*, p. 3; and Name withheld, *Submission 7*, p. 1.

39 Mr Marcus Kollakides, *Submission 12*, p. 14.

4.26 However, other submissions asserted that the JAS-39E Gripen, Eurofighter Typhoon and Dassault Rafale are not able to meet Australia's requirements.[40] ASPI advised the committee that 'there are few realistic alternatives to the F-35 at the moment—other potential choices are less stealthy, have poorer electronic warfare capability and are likely to be well overmatched by the F-35'.[41] SRWF asserted that the Super Hornet, F-16 Block 60, F-15, Eurofighter Typhoon, Rafael and Gripen had all been analysed and considered by Australia as options but that 'none of them were able to meet all of Australia's requirements'. SRWF advised that 'all were vulnerable to advanced threats' and 'did not provide the same opportunity to be continually upgraded to meet these evolving threats'.[42] APA asserted that the alternatives, whilst better than the F-35, were not viable:

> …claims that upgraded variants of the Boeing F-15 and F/A-18, LM F-16, Eurofighter Typhoon, Dassault Rafale or SAAB Gripen will be viable do not stand up to scrutiny. While all outperform the F-35 aerodynamically and aero/propulsively, and some have limited (~Mach 1.2) super-cruise, they lack the stealth capabilities of the PAK-FA, J-20 and J-31[43].

4.27 Defence assured the committee that alternative aircraft, including the Super Hornet, Eurofighter, Rafale and Gripen, were all considered and analysed extensively by Defence before its decision to acquire the F-35 was made:

> The ability of the F-35A to satisfy the Government's expectations of the air combat force was subject to a comprehensive analysis involving the full scope of available tools and techniques conducted over many years, including thousands of simulation runs and a series of human-in-the-loop mission simulator experiments. The best available performance data for both the F-35A and advanced threat systems were employed for these efforts. The combined results of this analysis indicated that the F-35A would be able to meet the Government's air combat requirements over the period of its service life.
>
> Aircraft considered to be alternatives to the F-35 were also analysed extensively by Defence. Alternatives considered included the Super Hornet, Eurofighter, Rafale and Gripen. The capabilities of the F-22 were assessed but it did not meet Australia's multi-role requirements due to its limited air to surface capability, noting also that US policy would not allow the F-22 to be sold to other nations. This extensive analysis identified where alternative platforms would be unable to meet all of Australia's requirements and highlighted the vulnerabilities of some of these platforms to advanced threats that F-35 capabilities overcome. In addition, the available

40 For example: Air Power Australia, *Supplementary Submission 9.2*, p. 2; Mr James Hicks, *Submission 42*, pp 7–9; Australian Strategic Policy Institute, *Submission 47*, p. 3; Department of Defence, *Submission 55*, p. 8.

41 Australian Strategic Policy Institute, *Submission 47*, p. 3.

42 Sir Richard Williams Foundation, *Submission 17*, p. 5.

43 Air Power Australia, *Supplementary Submission 9.2*, p. 2.

> alternatives were shown to have limitations in the ability to be modernised over their service life to defeat more complex threats beyond 2030.[44]

Unmanned

4.28 Dr Jai Galliott urged the committee to consider 'whether we have the right balance between piloted, optionally piloted, remotely piloted and even automatically piloted (autonomous) systems planned for the future ADF force structure'. Dr Galliott questioned whether Australia actually required the capabilities outlined in the Defence White Paper as well as questioning whether the F-35 represented a good return on investment when compared with an unmanned aerial vehicle (UAV):

> With this in mind, and the fact that Australia already has air superiority over its more immediate regional neighbours, the question for the committee ought to be whether Australia needs the capability to fight with the US against a major power in such an integrated but traditional fashion, especially when it comes at such great expense. My suggestion is that it does not. Indeed, it is not even obvious that we need a human in the loop (that is, a pilot in the cockpit). ..it is not at all obvious whether the margin of improvement offered by an aircraft like the F-35 (over a General Atomics MQ-9 Reaper or a purpose built combat drone, for example) represents a good return on investment or the sort of 'value for money' that the Australian people expect in times of relative austerity.[45]

4.29 Mr Roger Jennings noted that the RAAF 'has no unmanned multi-role attack-ISTAR [information, surveillance, target acquisition, and reconnaissance] aircraft'. He recommended that the RAAF purchase only 36 F-35A aircraft and acquire three types of unmanned aircraft:

> RAAF requires three types of unmanned aircraft to greatly strengthen its war fighting-ISTAR capabilities at minimum cost. Purchase 36 Improved Gray Eagle attack-ISTAR unmanned aircraft; 12 Predator B Guardian for maritime patrol and maritime attack; and 36 Predator C stealthy jet powered attack-ISTAR unmanned aircraft.[46]

4.30 SRWF noted that sixth-generation unmanned combat aircraft systems are currently under development, but that few if any of these will be available in operationally significant numbers before 2030:

> There are potential 6th generation unmanned combat aircraft systems under development such as the joint French-Swedish nEUROn, the UK's BAE Taranis, Northrop Grumman's X-47B and the US Navy's follow-on UCLASS program, and similar unmanned combat aircraft projects underway in Russia and China. But it is generally accepted that few if any of these will be available in operationally significant numbers before 2030.[47]

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44 Department of Defence, *Submission 55*, p. 8.

45 Dr Jai Galliott, *Submission 3*, pp 1–2.

46 Mr Roger Jennings, *Submission 53*, p. 2.

47 Sir Richard Williams Foundation, *Submission 17*, p. 15.

Other

4.31 The Medical Association for the Prevention of War (MAPW) asserted that 'Australia's security needs would be better and far more affordably addressed by using at least some of this expenditure to greatly increase our foreign aid and our diplomatic efforts towards the resolution of conflicts'. MAPW argued that Australia's foreign policy should be independent from the United States and focused on supporting mediation and other forms of conflict resolution and creating goodwill between Australia and other nations:

> Australia's diplomatic activity via the Department of Foreign Affairs and Trade (DFAT) is underfunded. Professor John Langmore, Assistant Director Research (Security and Political Engagement) in the Melbourne School of Government at Melbourne University (and former federal parliamentarian) states that the Australian diplomatic service has been starved of funds for 20 years and that we have fewer diplomatic posts overseas than any other of the G20 countries. DFAT does not have an integrated, focussed approach to supporting mediation or other forms of conflict resolution; we tend to instinctively respond to conflict by planning military action. In the 2014 budget, the Defence Department received 21 times as much as diplomacy and aid administration.
>
> Australia's overseas aid program, which could be a powerful means of creating goodwill between Australia and other nations, has also reached shamefully low levels. In 2014, in an astonishing act, Australia ceased its humanitarian aid to Iraq, the nation we had invaded and helped destabilise 11 years earlier; only a small amount of that aid has been restored. Such extraordinary foolishness undermines the building of positive relationships with other countries and peoples, in this case in a part of the world where Australia has already acquired many dangerous enemies. To send in the military, withdraw humanitarian aid, and expect to win "hearts and minds" defies credibility. We place far too much faith in the role of weapons and the capacity to kill in making us "secure".[48]

48 Medical Association for the Prevention of War, *Submission 50*, p. 6.

Chapter 5

Effects of the F-35 Program on Australian industry

Introduction

5.1 This chapter considers the effects of Australia's participation in the F-35 Program on local industry, including the cost and benefits of the program for Australian industry and the Australian economy.

5.2 The Australian F-35 Program has two fundamental goals:

- to deliver a new air combat capability that will meet Australia's air combat needs; and
- to deliver a strong industry base that supports the global F-35 capability and provides Australia with long-term economic benefits.[1]

The cost of the F-35 Program

5.3 The Department of Defence acknowledged that, historically, the F-35 Program has 'attracted significant public attention regarding cost and schedule', but assured the committee that it has 'stabilised and remained within the approved budget since the program was re-baselined in 2012'. Defence assured the committee that acquisition affordability 'remains one of the highest priorities for the F-35 Program', and that the Joint Program Office and prime contractors are working with F-35 partners and their participating industries in a Blue Print for Affordability Program, which 'aims to reduce the unit recurring flyaway cost of the F-35 to a price that compares with current fourth-generation fighters'.[2]

5.4 Defence advised that Australia's current F-35 Program total approved budget is AUD$17.1 billion (due to exchange rate updates). Within that, AUD$2.6 billion is contingency funding and the remaining AUD$14.5 billion includes the cost of the 72 F-35A aircraft, the support systems, training, weapons, and infrastructure, but not sustainment costs.[3]

5.5 Air Vice-Marshal Chris Deeble (Retd), Program Manager, Joint Strike Fighter, advised the committee that Defence has expended approximately $1 billion on the program to date, including the early Memorandum of Understanding (MoU) payments and the two stages of the program that have been approved by government to date.[4] The total approved budget also includes AUD$1.5 billion for F-35 facilities

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1 Department of Defence, *Submission 55*, p. 2.

2 Department of Defence, *Submission 55*, p. 12.

3 Air Vice-Marshal Chris Deeble (Retd), Program Manager, Joint Strike Fighter, Department of Defence, *Committee Hansard*, 22 March 2016, pp 66–70.

4 Air Vice-Marshal Chris Deeble (Retd), Program Manager, Joint Strike Fighter, Department of Defence, *Committee Hansard*, 22 March 2016, p. 66.

at RAAF Bases Williamtown and Tindal and other forward operating and support bases.[5]

5.6 Defence informed the committee that the Australian aircraft recurring flyaway cost 'is reducing significantly' and that 'based on current projections, the expected average unit cost of an Australian F-35 is US$90 million'. Defence noted that this is similar in price to the 'less capable fourth-generation aircraft' such as the latest version of the F/A-18 Super Hornet.[6]

5.7 Although the program has experienced delays and cost increases since it was first approved, the Sir Richard Williams Foundation pointed out that development cost increases are not passed on to partner countries.[7] As a partner nation, Australia pays an annual membership but does not incur research and development increases.[8]

5.8 Although the program's early cost overruns and schedule slippage were corrected in 2012 and the outlook now appears more stable, submitters raised concerns that the acquisition and through-life costs of the aircraft still remain unclear.[9] This may be due to a number of factors, some still unknown, including:

- annual production rates;
- design flaws;
- Australia-specific modifications;
- whether the total number of aircraft built will be less than expected; and
- whether estimated maintenance costs will be higher than expected.[10]

5.9 There are also difficulties regarding the various definitions of 'cost' as it is not always clear which definition is being used. As discussed in the submission from Mr Alan Williams, there is the 'unit recurring flyaway cost', the 'total unit flyaway cost', the 'procurement unit cost', the 'acquisition unit cost' and the 'life-cycle cost'.[11]

5.10 In terms of sustainment, there also remains the question of whether Australia will opt to sustain its aircraft in-country or choose a more global approach.[12] As previously mentioned, the global support solution for the F-35 fleet is still being

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5 Air Vice-Marshal Chris Deeble (Retd), Program Manager, Joint Strike Fighter, Department of Defence, *Committee Hansard*, 22 March 2016, p. 66.

6 Department of Defence, *Submission 55*, p. 12.

7 Sir Richard Williams Foundation, *Submission 17*, p. 6.

8 Dr Andrew Davies, Australian Strategic Policy Institute, *Committee Hansard*, 22 March 2016, p. 22.

9 David Archibald, *Submission 8*, p. 6; Geoffrey de Looze, *Submission 38*, p. 4; Medical Association for Prevention of War, *Submission 50*, p. 3.

10 Air Power Australia, *Supplementary Submission 9.2*, p. 3; Mr Alan Williams, *Submission 20*, p. 58; Australian Strategic Policy Institute, *Submission 47*, pp 29, 35 and 37.

11 Mr Alan Williams, *Submission 20*, p. 18.

12 Australian Strategic Policy Institute, *Submission 47*, p. 35.

developed. Until a model is decided, it isn't possible to define support costs; however, the Australian Strategic Policy Institute did provide the following commentary:

> If Australia opts for support as part of a global arrangement, economies of scale should be possible. The more 'sovereign' the support model, the higher the cost. But in any case it's expected that facilities for in-country F-35 operations and support will cost well over $1 billion. The best guess—and it's admittedly little more than that—is that the fixed costs for F-35 operations would be around $2 billion initially, with an annual ongoing cost of about 10% of that figure, or $200 million per year. In comparison, and providing a 'sanity check' on that estimate, the support cost of the initial tranche of 24 Super Hornets was initially budgeted at $230 million per year, after 'set-up' costs of around $1 billion.[13]

5.11 Defence advised that sustainment costs for complex capabilities are usually two to two-and-a-half times the cost of the acquisition. Through-life sustainment costs were estimated at $43 billion; however, further estimates will occur post-2020.[14] Defence also advised that 'similar to acquisition affordability, there is a program to reduce operating and support affordability cost by 30 per cent compared to 2012 estimates'.[15]

Australian Government Industry Support costs

5.12 One of the main outcomes of the F-35 Program is 'to deliver a strong industry base that supports the global F-35 capability and provides Australia with long-term economic benefits'.[16] In order to achieve this, the Australian Government has provided support to industry participants through a variety of programs, including:

- Financial investment support provided by the Export Finance and Insurance Corporation;
- Skilling Australia's Defence Industry Program, which aims to create pathways into the Defence sector and address any skills capability gaps which exist;
- Research and Development Tax incentive, which provides a tax offset for eligible spending on Research and Development registered with the Department of Industry, Innovation and Science;
- The 'Next Generation Manufacturing Investment Programme' and 'Automotive Diversification Programme', which were established to support Australian industry impacted by the closure of the car manufacturing industry by 2017;
- Early Stage Commercialisation, which is part of the Commercialisation Australia program providing funding and resources to accelerate the business

13 Australian Strategic Policy Institute, *Submission 47*, p. 35.

14 Air Vice-Marshal Chris Deeble (Retd), Program Manager, Joint Strike Fighter, Department of Defence, *Committee Hansard*, 22 March 2016, p. 70.

15 Department of Defence, *Submission 55*, p. 12.

16 Department of Defence, *Submission 55*, p. 2.

building process for Australian businesses, entrepreneurs, researchers and inventors looking to commercialise innovative intellectual property;

- Researchers in Business (Enterprise Connect), which provides funding to support the placement of researchers from universities or public research agencies into businesses where it is identified that such a placement would help to develop and implement a new idea with commercial potential; and
- Research and Development Start Program, which provides funding to support the development of new or improved products, processes, or services.[17]

5.13 Additionally, support has been provided by state governments, including:

- South Australian Innovation and Investment Fund, which provides grants to innovative job creation projects to strengthen South Australia's manufacturing and technology base following Mitsubishi Motors Australia Limited ceasing manufacturing operations in Adelaide; and
- Geelong Region Innovation and Investment Fund, which provides funding to support new investment to create new or additional business capacity.[18]

5.14 Furthermore, the Defence Industry Innovation Centre offers advice to Australian businesses on winning F-35 opportunities and the New Air Combat Capability Industry Support Program provides funding to support the development of new or improved capabilities.[19]

Australia's participation in the program

5.15 As an international partner in the F-35 Program, the Australian supply industry has the opportunity to compete for business with other partner nations on a 'best value' basis in F-35 global supply chains.[20] The program's industrial participation model ensures that industrial opportunities for Australian companies span across the life of the program—from production and sustainment through to follow-on development.[21] In effect, Australian companies can win work on the program as a result of a limited competitive process, but the work is contingent on Australia continuing with its planned purchase of the aircraft.[22]

5.16 International participation in the F-35 Program is divided into three levels according to the amount of money a country contributes to the program—the higher the amount, the greater the nation's voice with respect to aircraft requirements, design, and access to technologies gained during development.[23] Level 1 partner status,

17 Department of Defence, *Submission 55*, p. 26.

18 Department of Defence, *Submission 55*, p. 26.

19 Department of Defence, *Submission 55*, p. 27.

20 Department of Defence, *Submission 55*, p. 10.

21 Lockheed Martin, *Submission 46*, p. 12.

22 Australian Strategic Policy Institute, *Submission 47*, p. 23.

23 Mr Alan Williams, *Submission 20*, p. 4.

entered into by the United Kingdom (UK), requires approximately a 10 per cent contribution to aircraft development and allows for fully integrated office staff and a national deputy at director level. Level 2 requires an investment of US$1 billion and was entered into by Italy and the Netherlands. Australia, Denmark, Norway, Canada, and Turkey joined the F-35 Program as Level 3 partners, with contributions ranging from US$125 million to US$175 million.[24]

5.17 Australian industry participation in the F-35 Program commenced under the banner of the System Design Demonstration MoU in late 2002. Subsequently, the Production, Sustainment and Follow-on Development MoU was agreed between partner nations in 2006.[25] Prime contractors Lockheed Martin and Pratt & Whitney are not signatories to the Production, Sustainment and Follow-on Development MoU; however, in December 2006 the Department of Defence signed MoUs with both companies.[26]

5.18 Each MoU is supported by an Industry Participation Plan, a best-value model agreed upon by all program partner countries which contains potential design and production opportunities to be pursued in partnership with industry.[27] The best-value model is a program requirement to ensure the F-35 Program delivers an affordable aircraft solution to customers with rigorous quality standards, and competitive evaluations and business arrangements.[28]

Test and evaluation program

5.19 At the committee's public hearing, concerns were raised over the Australian component of the F-35 developmental test and evaluation program. In 2002 and again in 2009, Australia chose not to make a contribution to the developmental test and evaluation program but instead relied on other countries, such as the US and UK, to uncover technical and operational risks. According to Dr Keith Joiner, the decision to not place testers into the program outsourced Australia's sovereign insight into the program and wasted opportunities for Australians to work on the aircraft.[29]

5.20 In 2016, the US Director of Operational Test & Evaluation (DOT&E) released a report which identified F-35 testing issues across software, weapons integration and cybersecurity. DOT&E also acknowledged that the validation of the simulation model for the F-35 aircraft was incomplete, lacked leadership and was subjected to only a small percentage of testing.[30] Dr Joiner suggested to the committee that Australia

24 Mr Alan Williams, *Submission 20*, p. 4.

25 Department of Defence, *Submission 55*, p. 21.

26 Department of Defence, *Submission 55*, p. 21.

27 Department of Defence, *Submission 55*, p. 21.

28 Lockheed Martin, *Submission 46*, p. 13.

29 Dr Keith Joiner, Private capacity, *Committee Hansard*, 22 March 2016, p. 27.

30 Dr Keith Joiner, Private capacity, *Committee Hansard*, 22 March 2016, p. 27.

should increase its participation in the developmental test program and 'offer strongly to lead the validation of the JSF simulation model'.[31]

5.21 Defence informed the committee that two Australian Defence officials have been involved in the test and evaluation program since 2010, and that there are currently:

- four personnel at Eglin Air Force Base supporting the joint operational test team;
- two personnel at Lockheed Martin Fort Worth in engineering and logistics support roles; and
- two Australian pilots and one maintenance engineer operating at the Luke Air Force Base.[32]

5.22 Air Vice-Marshal Deeble assured the committee that personnel working within those environments provide Defence with significant insight into the program. Defence stated that it is confident that work is being done to address the issues raised in the DOT&E report.

Benefits to Australian industry

5.23 As a result of being able to compete for business on global F-35 Program supply chains, and with the support of government programs, Australian companies have won a number of significant contracts and secured over US$554 million worth of design and production work.[33] This figure is a combination of contracts awarded by Lockheed Martin and its suppliers, contracts awarded by Pratt & Whitney, and investments made by the Australian government to advantage Australian industry to win these contracts.[34] This figure is expected to increase significantly over the life of the program as it matures, resulting in rising production volumes and future sustainment opportunities.[35] The nature and scale of the contribution is illustrated in the table below.

31 Dr Keith Joiner, Private capacity, *Committee Hansard*, 22 March 2016, p. 28.

32 Air Vice-Marshal Chris Deeble (Retd), Program Manager, Joint Strike Fighter, Department of Defence, *Committee Hansard*, 22 March 2016, p. 66.

33 Lockheed Martin, *Submission 46*, p. 13.

34 Lockheed Martin, *Submission 46*, p. 13.

35 Quickstep Holdings Ltd, *Submission 26*, p. 1.

Table 5.1—Source and value of Australian industry contracts to date

Source	Value of contracts (USD, millions)	Number of existing/completed contracts
System Design and Development (SDD)	$171.9	62
Contracts arising from SDD opportunities: Lockheed Martin	$151.9	13
Production opportunities: Lockheed Martin	$199.7	34
Production opportunities: Pratt & Whitney	$21.6	7
Production opportunities: Other	$9.1	2
Sustainment	$0.3	1
Total	**$554.5**	**119**

Source: Department of Defence, *Submission 55*, p. 23.

5.24 The F-35 Program affords Australian industry the opportunity to compete for business to produce parts on all of the aircraft in the program—presently more than 3100 aircraft through to 2040.[36] All of these opportunities consist of direct work on a wide range of F-35 components. Contracts range from the provision of treated raw materials to high-end manufacturing of components and sub-assemblies, as well as software development and production of sensitive technologies.[37]

5.25 Many submitters agreed that the impact of the F-35 Program on local Australian industry, and subsequently the Australian economy, has been positive. However, it should be noted that Australia has made significant efforts to artificially support local companies to become part of global supply chains.[38] This has been in the form of a variety of government programs, such as financial investment through the Export Finance and Insurance Corporation, innovation grants, and tax offsets. A full list is provided at the end of the chapter.

5.26 Industrial participants listed a range of benefits received since their involvement in the program, including: global supply chain opportunities, capability and network development, job creation, long-term investment, increased skills and experience, and opportunities for future work. Some of these are discussed below.

36 Lockheed Martin, *Submission 46*, p. 12.

37 Department of Defence, *Submission 55*, p. 22.

38 Australian Strategic Policy Institute, *Submission 47*, p. 23.

Global supply chain opportunities

5.27 The F-35 Program was recognised in the 2016 Defence Industry Policy Statement as a key example of how a capability requirement can be used to build new global supply chain opportunities for Australian defence industry.[39] As noted by Defence:

> The Joint Strike Fighter Program is about much more than just the delivery of a new fighter capability. It is a catalyst for change for both Australian Defence capability and outcomes for Australian defence industry…The Program adopted a new capability acquisition strategy that allowed Australian industry to participate in all stages of the capability life cycle, from design through to sustainment. Importantly, Defence's Joint Strike Fighter Program Office includes an industry team which has brought about a cultural shift in the way industry and Defence capability managers engage. As a result, the fifth generation aircraft is providing a pathway for industry to move closer to the heart of capability development and sustainment, effectively positioning industry as a Fundamental Input to Capability. To date, a total of US$554.5 million in contracts has been secured by Australian defence industry in Joint Strike Fighter design and production, with more opportunities to become available as rates of aircraft production increase and the sustainment model develops. The Joint Strike Fighter will be sustained by a global supply chain that will eventually service over 3000 F-35 aircraft worldwide…
>
> Maximising opportunities for Australian defence industry in the global sustainment system for the Joint Strike Fighter will require an even closer relationship between industry and Defence in the future. The global supply chain opportunities, provided to Australian defence industry through the Joint Strike Fighter Program, are a good example of how largescale capability projects can provide real benefit and growth to Australian small to medium enterprises. Defence will, in collaboration with CDIC [Centre for Defence Industry Capability], seek to develop similar models for Australian industry involvement in future major ADF capability projects.[40]

Capability development

5.28 Significant research and development has been undertaken by industry in order to win work on the F-35 Program. A number of companies have made use of the government's New Air Combat Capability Industry Support Program, which was established to provide funding to Australian companies to support the development of new or improved capabilities that may enhance the ability to win work in the production, sustainment and modernisation phases of the F-35 Program.[41]

5.29 Australia's commitment has resulted in significant capability improvements within the industry, including developments in technology, manufacturing and

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39 Department of Defence, *2016 Defence Industry Policy Statement*, p. 50.

40 Department of Defence, *2016 Defence Industry Policy Statement*, pp 53–54.

41 Department of Defence, *Submission 55*, p. 27.

staffing, and improved efficiencies and processes. Australian companies are currently providing a range of advanced manufacturing techniques to the supply of F-35 components. These techniques include moulding, curing, casting, plating, vacuum brazing, laser welding, close tolerance machining and complex assembly.[42]

5.30 Innovative technologies have been developed in thermal processing, and in-country commercial chemical processing has been established.[43] Some companies have gained Nadcap (industry approved) accreditation and improved their chances of winning future aerospace work.[44] Heat Treatment Australia observed:

> Expansion of facilities and processes at HTA are a direct result of involvement in the F-35 program, specifically the new processes are required to fill gaps in F-35 supply chains and to ensure Australia is able to compete on all available work packages. The expanded facility at HTA will also fill identified gaps in Australia's advanced manufacturing industrial framework.[45]

5.31 Exposure to upskilling has improved overall capabilities and efficiencies of companies involved in the F-35 Program. According to submitters, training provided by Defence contractors to Australian companies has improved manufacturing quality and speed, as well as business processes and systems.[46] Marand Precision Engineering noted:

> Both BAE Systems and Lockheed Martin have provided considerable training, assistance, guidance and coaching in areas such as Quality Systems, Proposal Preparation, Lean Manufacturing, Supply Chain Management, Relationship Management and Cyber Security. This has made Marand more robust, capable and professional.[47]

5.32 Efforts to transfer technology such as advanced composite manufacturing and high-speed metal machining between companies were also highlighted by submitters as building long-term industrial capability.[48]

Network development

5.33 As a result of winning F-35 supply contracts, Australian companies with previously limited exposure to the defence aerospace sector, have been able to

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42 Quickstep Holdings Ltd, *Submission 26,* p. 3.

43 Lovitt Technologies Australia and Technomold Australia, *Submission 31,* pp 4–5; Heat Treatment Australia Pty Ltd, *Submission 32,* p. 2.

44 Lovitt Technologies Australia and Technomold Australia, *Submission 31,* p. 4; Heat Treatment Australia Pty Ltd, *Submission 32,* p. 1.

45 Heat Treatment Australia Pty Ltd, *Submission 32,* p. 2.

46 Marand Precision Engineering Pty Ltd, *Submission 23,* p. 3; and Levett Engineering Pty Ltd, *Submission 39,* p. 3;

47 Marand Precision Engineering Pty Ltd, *Submission 23,* p. 3.

48 Northrop Grumman Australia, *Submission 41,* p. 2; Bae Systems Australia, *Submission 49,* p. 3.

develop industrial networks locally and internationally.[49] For example, local networks have arisen between BAE Systems Australia and its supply chain companies, including:

- Sutton Tools for the supply of cutting tools;
- Vipac Engineers to optimise machining efficiency;
- Axiom Diemold to provide roughing operations; and
- Heat Treatment Australia for the treatment of components.[50]

5.34 International relationships have also developed between Australian companies and Original Equipment Manufacturers, aerospace companies, and defence organisations.[51] As Quickstep Holdings noted, Northrop Grumman has provided it with new F-35 orders every year since the program's inception.[52]

Job creation

5.35 Many submitters asserted that the F-35 Program has delivered considerable employment opportunities to Australian industry.[53] Marand Precision Engineering told the committee that the F-35 Program has helped to offset declining employment rates in the automotive manufacturing industry by engaging a large number of people out of its engineering and manufacturing workforce.[54] Many submitters described the need to increase staff numbers to meet the demands of the program, as well as the need to hire a range of other services, for example to build facilities, supply equipment or transport goods.[55]

5.36 In the case of Levett Engineering, the ability to secure contracts on the F-35 supply chain transformed the business from a small machine shop which operated one shift a day, five times a week for domestic customers, to an aerospace exporter

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49 For example: Defence Materials Technology Centre, *Submission 24*, p. 3; Quickstep Holdings Ltd, *Submission 26*, p. 3; Lovitt Technologies Australia and Technomold Australia, *Submission 31*, p. 3; Ferra Engineering Australia, *Submission 43*, p. 2.

50 Defence Materials Technology Centre, *Submission 24*, p. 3.

51 Chemring Australia, *Submission 18*, p. 1; Lovitt Technologies Australia and Technomold Australia, *Submission 31*, pp 1–5.

52 Quickstep Holdings Ltd, *Submission 26*, p. 3.

53 For example: Marand Precision Engineering Pty Ltd, *Submission 23*; Quickstep Holdings Ltd, *Submission 26*; Lovitt Technologies Australia and Technomold Australia, *Submission 31*; Heat Treatment Australia Pty Ltd, *Submission 32*; Levett Engineering Pty Ltd, *Submission 39*; TAE Gas Turbines Pty Ltd, *Submission 45*; BAE Systems Australia, *Submission 49*.

54 Marand Precision Engineering Pty Ltd, *Submission 23*, p. 4.

55 For example: Marand Precision Engineering Pty Ltd, *Submission 23*, p. 2; Quickstep Holdings Ltd, *Submission 26*, p. 1; Lovitt Technologies Australia and Technomold Australia, *Submission 31*, p. 2; Heat Treatment Australia Pty Ltd, *Submission 32*, p. 2; Levett Engineering Pty Ltd, *Submission 39*, p. 3; TAE Gas Turbines Pty Ltd, *Submission 45*, p. 2; BAE Systems Australia, *Submission 49*, p. 3.

running three shifts a day, six days a week and which struggles to keep up with demand.[56] Similarly, Heat Treatment Australia stated:

> As a direct result of the F-35 program, HTA has experienced significant growth leading to expansion of our facilities in Brisbane and Melbourne. To date our additional investment in aerospace and defense projects has included new equipment, expanded facilities, improved quality systems, increased employment and increased employee skills sets. These efforts are targeted at fulfilling Australian industry supply chain requirements for the F-35 program.[57]

5.37 Many submitters also expressed their expectations of future expansion and job creation as the program matures towards peak production and sustainment.[58] BAE Systems predicted that:

> A holistic approach to JSF sustainment, in particular Component MRO&U, will maximise job opportunities in the high technology sector, likely requiring specialists in sensor fusion, electronic warfare, digital technology and advanced communications systems.[59]

5.38 However, it was pointed out by the Medical Association for the Prevention of War that 'putting billions of dollars into any sector of society will create jobs'.[60]

Long-term investment

5.39 As the life of the F-35 Program is expected to extend over a significant number of years, Australian companies involved in supply chains have advised that they have been able to make long-term capital investments in factories and equipment.[61] For example, over the past seven years, BAE Systems invested significantly in its local facilities in Williamtown, Edinburgh, Melbourne and Canberra, to ensure it was ready for the production of F-35 aircraft as well as long-term sustainment.[62]

5.40 Other companies have experienced growth over a number of years and invested in high-tech machinery.[63] Lovitt Technologies Australia has been

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56 Levett Engineering Pty Ltd, *Submission 39,* pp 2–3.

57 Heat Treatment Australia Pty Ltd, *Submission 32,* p. 3.

58 For example: Marand Precision Engineering Pty Ltd, *Submission 23,* p. 2; Quickstep Holdings Ltd, *Submission 26,* p. 1; Lovitt Technologies Australia and Technomold Australia, *Submission 31,* p. 2; BAE Systems Australia, *Submission 49,* p. 3.

59 BAE Systems Australia, *Submission 49,* p. 3.

60 Medical Association for Prevention of War, *Submission 50,* p. 3.

61 For example: Lovitt Technologies Australia and Technomold Australia, *Submission 31,* p. 3; Heat Treatment Australia Pty Ltd, *Submission 32,* p. 3; Levett Engineering Pty Ltd, *Submission 39,* p. 3; BAE Systems Australia, *Submission 49,* p. 2.

62 BAE Systems Australia, *Submission 49,* p. 2.

63 For example: Quickstep Holdings Ltd, *Submission 26,* p. 1; Lovitt Technologies Australia and Technomold Australia, *Submission 31,* p. 3; Ferra Engineering Australia, *Submission 43,* p. 1.

manufacturing parts on F-35 aircraft for Lockheed Martin since 2006, investing in high-tech machinery previously unavailable in Australia:

> Among these investments has been the installation of a Makino T1 machining centre, the only one of its kind in Australia and the tenth installed worldwide. This machine is specifically designed for efficient machining of large titanium components and runs around the clock. Another investment has been the installation of a Mitutoyo Coordinate Measuring Machine (CMM) with an inbuilt laser scanner, this has allowed us to measure complex assemblies in minutes rather than hours without even touching the part…Since 2013 Lovitt has employed 23 new staff members and invested $4.9M in the latest, most efficient machines in Australia.[64]

5.41 Submitters advised that participation in F-35 global supply chains has delivered considerable growth to Australian companies in staffing, equipment and revenue and that future growth is anticipated as the program reaches its peak production and sustainment cycles.[65]

Ongoing benefits to industry

5.42 The F-35 Program has increased Australian industry's ability to win future work by creating transferable skills and capabilities. Several submitters noted that many of the skills and capabilities developed in the strategic context of the F-35 Program are readily transferable to other sectors within and outside the defence arena.[66] As the Defence Materials Technology Centre explained:

> …it is worth noting that key elements of the industrial sector development arrangements in the JSF program are being investigated for replication elsewhere in Defence, for example for the Future Submarine Program. Industries who have the enterprise and technical capability to participate in one program will have clear advantages in moving into programs in another domain. The JSF program, as one of the early examples of Australian industry participation at scale in a global supply chain, has provided Australian industry with critical tools for participation in other programs.[67]

5.43 Submitters also asserted that Australian companies have been provided with a significant marketing tool to demonstrate their work to potential customers. One Australian company has already taken advantage of the networks and capabilities developed to meet F-35 production standards and secured additional work with other areas of Lockheed Martin. As Lockheed Martin noted, 'the Australian company

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64 Lovitt Technologies Australia and Technomold Australia, *Submission 31,* p. 3.

65 For example: Quickstep Holdings Ltd, *Submission 26,* p. 3; Heat Treatment Australia Pty Ltd, *Submission 32,* p. 3; Levett Engineering Pty Ltd, *Submission 39,* pp 2–3.

66 For example: Chemring Australia Pty Ltd, *Submission 18,* p. 1; Marand Precision Engineering Pty Ltd, *Submission 23,* p. 2; Defence Materials Technology Centre, *Submission 24,* p. 1; Quickstep Holdings Ltd, *Submission 26,* p. 4; Heat Treatment Australia Pty Ltd, *Submission 32,* pp 2–3; Levett Engineering Pty Ltd, *Submission 39,* p. 3.

67 Defence Materials Technology Centre, *Submission 24,* p. 5.

Quickstep has applied skills acquired through JSF participation to win contracts for exporting composite aircraft parts to Lockheed Martin's international C-130J Super Hercules program'.[68] Similarly, Levett Engineering commented that its bids for non-JSF work were successful because companies such as Boeing were aware of Levett's work for Lockheed Martin.[69]

5.44 By working on F-35 supply chains, Australian companies have been able to demonstrate their technical and manufacturing capabilities to a range of potential contractors.[70] As Marand Precision Engineering pointed out:

> Demonstrated ability in producing state-of-the-art F35 products certainly gives Marand and other Australian companies significant leverage when marketing their capabilities overseas and has led to previously unforeseen opportunities being secured on the strength of potential customers seeing what we have done on F35. Within the global aerospace industry the relationships that have been developed as a result of Marand's participation in the F-35 program are already resulting in new opportunities being identified and pursued both within and outside of F35.[71]

5.45 As a result of its involvement on the F-35 Program, Ferra Engineering has expanded its operations by opening a facility in Oklahoma in 2013. While the facility was initially established to support the program, it presented the company with additional business opportunities that resulted in further work being performed in Australia.[72]

5.46 Furthermore, the requirements of F-35 production have necessitated advancements in capabilities that will allow companies to take on more advanced projects in the future. For example, Heat Treatment Australia has received international recognition for its pioneering work in thermal processing, and accessed international markets, new revenue streams, and new marketing opportunities.[73]

Follow-on modernisation, regional maintenance and global support solution

5.47 Aside from the industrial design and production opportunities, there are also opportunities for Australian companies to participate in the follow-on modernisation, regional maintenance, and global support solution of the aircraft.[74] The follow-on modernisation program includes: adding new weapons, more efficient systems, lighter

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68 Lockheed Martin, *Submission 46,* p. 13.

69 Levett Engineering Pty Ltd, *Submission 39,* p. 3.

70 For example: Marand Precision Engineering Pty Ltd, *Submission 23,* pp 1–2; Heat Treatment Australia Pty Ltd, *Submission 32,* p. 1; Ferra Engineering Australia, *Submission 43,* p. 2; Lockheed Martin, *Submission 46,* p. 13; BAE Systems Australia, *Submission 49,* p. 3.

71 Marand Precision Engineering Pty Ltd, *Submission 23,* pp 2–3.

72 Ferra Engineering Australia, *Submission 43,* p. 2.

73 Heat Treatment Australia Pty Ltd, Submission 32, p. 3.

74 Lockheed Martin, *Submission 46,* p. 13.

structures and newer tools, and will evolve over the life of the global fleet.[75] According to Lockheed Martin, the modernisation program will be shared by partner nations, as detailed in the Industrial Participation plan, and opportunities will evolve throughout the service life of the global fleet.[76]

5.48 In 2015, the US Government assigned Australia regional F-35 depot maintenance responsibilities for airframes and engines.[77] BAE Systems (assigned airframe maintenance), and TAE Gas Turbines (assigned engine maintenance) have begun planning in order to meet the expected increases in volume and capability.[78] The Joint Program Office has indicated that as more aircraft arrive in the Asia-Pacific region, Australia's depot maintenance capability may eventually be supplemented by Japan.[79]

5.49 A global support solution for sustainment of the aircraft is still being developed; however, the Department of Defence stated that it expects Australia's defence industry base will be used to contribute to an affordable F-35 global support solution.[80]

Benefits to the Australian economy

5.50 According to submissions from industrial participants,[81] the F-35 Program has provided a range of flow-on benefits to the Australian economy, including:

- growth in employment;
- expansion of facilities and equipment;
- transferable skills and capabilities;
- export opportunities;
- innovation;
- extension of supply chain opportunities to other Australian businesses; and
- research and development.

5.51 However, the committee was told that at least one Australian company has already been forced into liquidation due to delays and reductions in its F-35

75 Lockheed Martin, *Submission 46*, p. 13.

76 Lockheed Martin, *Submission 46*, p. 13.

77 Department of Defence, *Submission 55*, p. 3.

78 TAE Gas Turbines Pty Ltd, *Submission 45*, p. 2; and BAE Systems Australia, *Submission 49*, p. 1.

79 Department of Defence, *Submission 55*, p. 11.

80 Department of Defence, *Submission 55*, pp 11–12.

81 For example: Chemring Australia Pty Ltd, *Submission 18*; Marand Precision Engineering Pty Ltd, *Submission 23*; Defence Materials Technology Centre, *Submission 24*; Quickstep Holdings Ltd, *Submission 26*; Lovitt Technologies Australia and Technomold Australia, *Submission 31*; Heat Treatment Australia Pty Ltd, *Submission 32*; Levett Engineering Pty Ltd, *Submission 39*; Ferra Engineering Australia, *Submission 43*; BAE Systems Australia, *Submission 49.*

contracts.[82] Although the strength of the Australian dollar and slow-down in Defence spending contributed to the company's voluntary administration, the company cited the cancellation of F-35 engine contracts as a major factor.[83]

5.52 One submitter expressed uncertainty as to the value Australia would gain from future potential F-35 contracts.[84] In 2007, it was reported by the media that Australian industry would reap potential earnings of AUD$9 billion over its three decade involvement in the F-35 Program.[85] In 2010, it was reported that Lockheed Martin estimated that, 'over the 20 year production life of the JSF, the Australian share of work is currently projected to be somewhere between $11.5 and $12 billion, with further opportunities to follow'.[86] In 2015, Air Vice-Marshal Deeble, Program Manager, Joint Strike Fighter, estimated that 'Australian industry stands to win in excess of $1.5 billion in JSF-related production and support work over the life of the JSF program'.[87] Now in 2016, Defence has estimated that:

> …the potential total contracted value of the opportunities currently being worked by Australian industry could reach US$2 billion by 2023, assuming businesses are able to maintain globally competitive levels of performance on price, schedule and quality. If Australian companies continue to remain competitive in production then contracts to the value of US$4 billion are feasible out to the end of production in 2035.[88]

5.53 A forecast of the cumulative value of contracts secured by Australian Industry for F-35 design and production is illustrated in the table below.

82 Mr Eric Palmer, *Submission 19*, p. 7.

83 'JSF delays ground Aust parts maker', *The Canberra Times*, 21 September 2011, http://www.canberratimes.com.au/national/jsf-delays-ground-aust-parts-maker-20110921-1wqdg.html, (accessed 26 August 2016).

84 Mr Eric Palmer, *Submission 19*, p. 7.

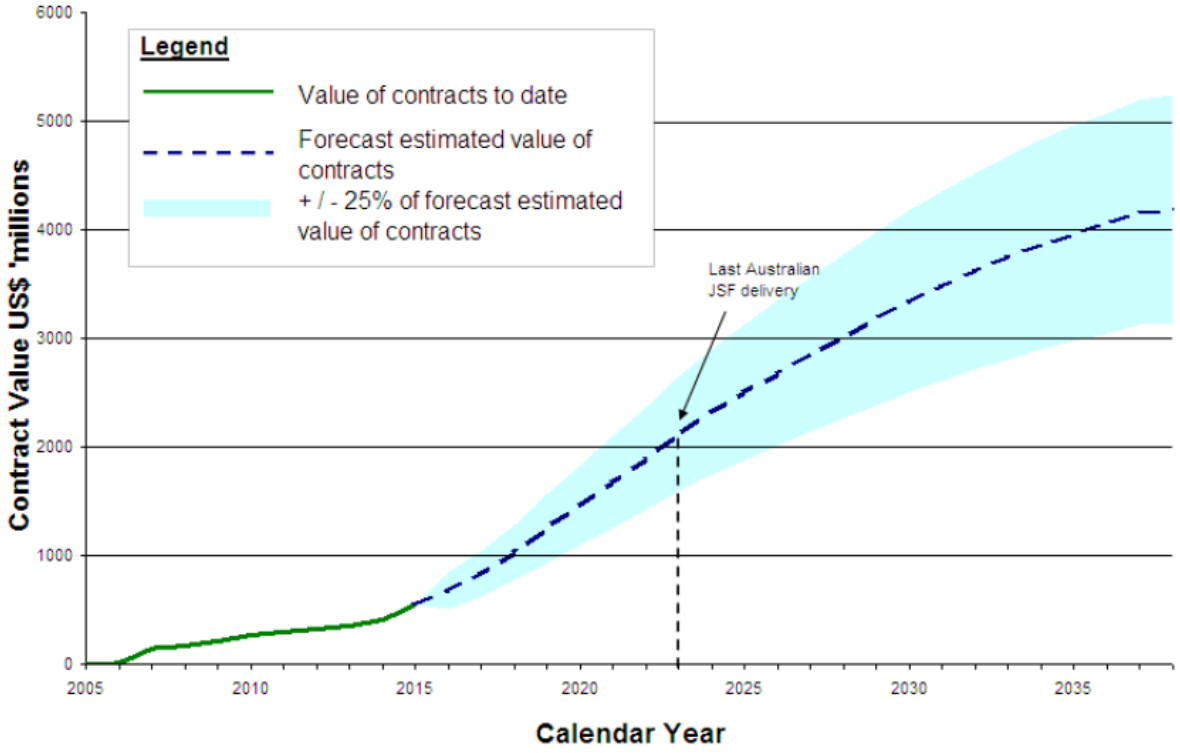
85 '$9bn bonanza in F-35 deal', *The Australian*, 23 March 2007, http://www.theaustralian.com.au/business/aviation/bn-bonanza-in-f-35-deal/story-e6frg95x-1111113205999, (accessed 26 August 2016).

86 'JSF – Australia Industry Participation', *Asia Pacific Defence Reporter*, http://www.asiapacificdefencereporter.com/articles/1/JSF-Australia-Industry-Participation, (accessed 26 August 2016).

87 'First Australian-made vertical tails installed on F-35', *CASG Bulletin*, http://www.defence.gov.au/dmo/NewsMedia/DMOBulletin/First-Australian-made-vertical-tails-installed-on-F-35, (accessed 26 August 2016).

88 Department of Defence, *Submission 55*, p. 10.

Table 5.2—Forecast cumulative value of contracts secured by Australian Industry for F-35 design and production



Source: Department of Defence, *Submission 55*, p. 24.

Chapter 6

Committee view and recommendations

6.1 During this inquiry the committee has considered the planned acquisition of the F-35A Lightning II Joint Strike Fighter and its ability to fulfil Australia's future air defence needs. The committee received evidence criticising the F-35A and raising concerns regarding the aircraft's performance in testing and subsequent delays to the acquisition timeline. Many submitters called for the aircraft's procurement to be cancelled.

6.2 Notwithstanding the criticisms, the committee is satisfied that the F-35A is the only aircraft able to meet Australia's strategic needs for the foreseeable future, and that sufficient progress is being made in the test and evaluation program to address performance issues of concern. The committee is not convinced that any of the available alternative aircraft raised in evidence are capable of meeting Australia's air defence needs. The committee accepts that the F-35A will provide the air combat capability outlined by the Defence White Paper, and will be able to defeat airborne threats, prosecute attacks against both land and sea surface targets and support Australia's land and maritime forces. The committee notes the F-35A's role in Plan Jericho, and believes that it is the best available aircraft to provide Australia with an integrated and networked force as well as providing compatibility of systems with allies.

6.3 Nonetheless, in light of the serious problems that led to a re-baselining of the F-35 program in 2012, and the ongoing issues identified by the United States Director of Operational Test and Evaluation (DOT&E), the committee retains a healthy scepticism towards assurances by Defence regarding cost, schedule and capability outcomes of the F-35A.

Performance of aircraft in testing

6.4 A number of submitters and witnesses raised concerns regarding the F-35's manoeuvrability and flight capabilities; stealth capabilities; mission systems; mission data loads and Autonomic Logistics Information System (ALIS); and escape system. As noted in chapter 3, it is difficult to accurately understand and critique the capabilities of the F-35A without access to detailed classified performance data. As such, the committee cannot draw definitive conclusions regarding the details of the F-35A's performance in testing. Nonetheless, it has confidence in the assessments made by Defence regarding both the air combat capabilities required by Australia and the F-35A's ability to meet these requirements.

6.5 The committee acknowledges the concerns of submitters regarding the F-35A's manoeuvrability and flight performance, but is satisfied that the F-35A's capabilities are appropriate for its purpose as a multi-role aircraft. Furthermore, the committee is satisfied that the F-35 offers better stealth and electronic warfare capabilities than any other available aircraft. The committee is, however, concerned by ongoing issues regarding the stability of mission systems software and the schedule risk that this engenders.

6.6 Defence noted that software development is 'effectively complete' and is now the 'main focus of the ongoing test and evaluation program'. It advised that, as at January 2016, the final software build had completed 50 per cent of baseline test points, but that 'significant test points are yet to be undertaken and issues found will need to be rectified'. However, Defence noted that there is schedule risk associated with the completion of the test and evaluation program and incorporation of fixes to meet the scheduled completion of the System and Development and Demonstration phase by the end of 2017.[1] Furthermore, the United States Director of Operational Test and Evaluation (DOT&E) 2015 annual report found that 'full block 3F mission systems development and testing cannot be completed by May 2017, the date reflected in the most recent Program Office schedule', estimating that the program is not likely to finish Block 3F development and flight testing prior to January 2018.[2] United States Lieutenant General Christopher Bogdan assured the committee that the issues are being identified and resolved.[3] However, the committee is concerned that any further delays to the acquisition timeline may risk the creation of a capability gap.

Acquisition schedule and capability gap

6.7 The re-baselining of the F-35 Program deferred the procurement of the Australian F-35A by two years, resulting in initial operational capacity moving from 2018 to 2020.[4] Australia now plans to ferry the first two F-35 aircraft to Australia in late 2018, with initial operational capability planned for 2020 with the establishment of 3 Squadron (3SQN) to be followed by 2 Operational Conversion Unit (2OCU) and supporting systems and infrastructure at RAAF Base Williamtown. Final operational capability is planned for 2023 with the establishment of 77SQN at RAAF Base Williamtown and 75SQN at RAAF Base Tindal.[5]

6.8 Defence advised that the F-35 Program schedule has 'stabilised' since the re-baselining in 2012, with 'any movements being managed through schedule margins built into the Program'. Defence assured the committee that it is 'closely monitoring test point achievement and software maturity' and has 'built in additional schedule margin to manage this risk' to ensure that Australian initial operating capacity is met in 2020.[6] The Chief of the Air Force, Air Marshal Leo Davies, assured the committee that he is confident that delays in the development of the F-35 would not result in a capability gap.[7] However, the committee is not convinced that a suitable mitigation strategy has been prepared to address this risk.

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1 Department of Defence, *Submission 55*, p. 13.

2 United States Director of Operational Test and Evaluation, *F-35 Joint Strike Fighter*, 2015, p. 35–36.

3 Lieutenant General Christopher Bogdan, *Submission 56*, p. 10.

4 Department of Defence, *Submission 55*, p. 13.

5 Department of Defence, *Submission 55*, p. 6.

6 Department of Defence, *Submission 55*, p. 13.

7 *Committee Hansard*, 22 March 2016, p. 66.

6.9 Life extension work on the classic Hornet fleet has extended its retirement date from 2015 to 2022 and beyond; however, evidence received from the Sir Richard Williams Foundation and the Australian Strategic Policy Institute (ASPI) indicated that the scope for further extension beyond this date is limited, costly, and will result in a decrease of capability.[8] Considering the history of significant changes to the acquisition schedule over the life of the F-35 Program, including the recent re-baselining, together with the limited scope and considerable cost to further extend the life of the classic Hornet fleet, the committee considers it prudent for Defence to develop a hedging strategy to mitigate the risk of a capability gap resulting from further delays.

6.10 The committee notes ASPI's advice that the 'most sensible hedge' would be to order another tranche of F/A-18F Super Hornets. ASPI explained that this would be the best option as no other fifth-generation aircraft is available on the world market; most, if not all, of the fixed costs of acquiring the Super Hornet have already been borne; and any other type of aircraft would bring with it new supply chains and flight and ground crew training requirements, putting strain on the RAAF's capacity to absorb the several other new types of aircraft in the pipeline. ASPI noted that, taking into consideration a three or more year lead time for the delivery of a new-build Super Hornet, a decision would need to be made by 2019 at the latest.

Recommendation 1

6.11 The committee recommends that the Department of Defence develop a hedging strategy to address the risk of a capability gap resulting from further delays to the acquisition of the F-35A. The strategy should be completed by 2018 and capable of implementation by 2019 at the latest.

Potential alternatives

6.12 The committee received evidence against the procurement of the F-35A which asserted that Australia should instead acquire the F-22 Raptor. Air Power Australia (APA), in particular, was highly critical of the F-35A, which it described as 'structurally obsolete'.[9] APA asserted that the F-35A is not capable of meeting Australia's air combat capability needs, warning that 'advances in both Russian and Chinese aircraft, air-to-air missiles, cruise missiles, and smart bombs now challenge the primacy of Western air power, believed unbeatable since the Cold War'.[10] APA adamantly asserted that the F-22 Raptor is the 'only alternative' and called for the United States to abandon the F-35 program in favour of restarting production of the F-22.

6.13 The committee is sceptical of the accuracy of analysis and conclusions calling into question the suitability of the F-35A, noting that the information necessary to

8 Australian Strategic Policy Institute, *Submission 47*, p. 4; Sir Richard Williams Foundation, *Submission 17*, pp 4–5.

9 Air Power Australia, *Supplementary Submission 9.2*, p. 3.

10 Air Power Australia, *Submission 9*, p. 2.

accurately assess the capability of the aircraft is classified, as is information regarding current generation Russian and Chinese developmental aircraft. Furthermore, after seeking comment from a range of other witnesses regarding analysis such as APA's Zero-One Comparative Technique (ZOCT) Table, the committee finds its conclusions to be unpersuasive. However, even if the data and conclusions were beyond doubt, the F-22 is not in production and is unlikely to ever be reinstated to production. Even if it were, despite rumours to the contrary, the sale of the F-22 'to any foreign government' remains prohibited by the United States Congress. As such, the committee is unconvinced that the F-22 is a realistic alternative to the F-35A.

6.14 The committee received some evidence from submitters and witnesses regarding the JAS-39E Gripen, Eurofighter Typhoon and Dassault Rafale, in addition to suggestions regarding unmanned aircraft. However, the evidence was not able to demonstrate that these aircraft would be better able to meet all of Australia's requirements. The committee therefore concludes that the F-35A remains the only currently viable aircraft that is capable of meeting Australia's near term strategic needs and as such, should be a key element of Australia's air combat capability.

Benefits to Australian industry

6.15 The evidence received indicated that the impact of the F-35 Program on local Australian industry, and subsequently the Australian economy, has been positive. As a result of being able to compete for business on global F-35 Program supply chains, and with the support of government programs, Australian companies have won a number of significant contracts and secured over US$554 million worth of design and production work.[11] This is a figure which is expected to increase significantly over the life of the program as it matures, resulting in rising production volumes and future sustainment opportunities.[12]

6.16 Australian industry submitters and witnesses told the committee that they have received a range of benefits from their involvement in the F-35 Program, including: capability and network development; job creation; long-term investment; increased skills and experience; and opportunities for future work. The committee was pleased to hear that the F-35 Program has delivered considerable employment opportunities to Australian industry as well as helping to offset declining employment rates in the automotive manufacturing industry by engaging a large number of people out of its engineering and manufacturing workforce.

Sovereign industrial capabilities

6.17 The committee is concerned that the potential for other nations to be prioritised over Australia for the provision of repair parts and for the development of software (e.g. mission data files, electronic warfare) may negatively impact Australian capability. The committee notes that the support solution for sustainment is still under development; however it is concerned that the F-35's reliance on mission data loads

11 Lockheed Martin, *Submission 46*, p. 13.

12 Quickstep Holdings Ltd, *Submission 26*, p. 1.

produced by the US Reprogramming Laboratory, together with the Autonomic Logistics Information System (ALIS) and global support model could impact Australia's sovereign ability to make decisions around how, when, and where we deploy capability.

6.18 A balance must be found between the benefits of the global support solution and maintaining an acceptable level of sovereignty regarding the maintenance of Australian capability. As such, the committee strongly supports Defence's efforts to develop mission data reprogramming capabilities in Australia. Furthermore, the committee encourages efforts to establish Australia as the F-35 Asia-Pacific maintenance and sustainment hub. This would have the dual benefit of increasing Australian industry participation in the F-35 global support solution as well as developing in-country maintenance and support capabilities.

Recommendation 2

6.19 The committee recommends that the Department of Defence develop a sovereign industrial capability strategy for the F-35A to ensure that Australian aircraft can be maintained and supported without undue reliance on other nations.

Recommendation 3

6.20 The committee recommends that the government endeavour to establish Australia as the Asia-Pacific maintenance and sustainment hub for the F-35.

Senator Alex Gallacher
Chair

Senator Chris Back
Deputy Chair

Dissenting report by the Australian Greens

JSF: Too big, too failed

> **Only an alert and knowledgeable citizenry can compel the proper meshing of huge industrial and military machinery of defence with our peaceful methods and goals, so that security and liberty may prosper together.**
>
> President Dwight D. Eisenhower, Farewell Address, 17 January 1961

> **The F35 program 'is actually not on a path toward success, but instead on a path toward failing to deliver the full Block 3F capabilities for which the Department is paying almost $400 billion.'**
>
> Michael Gilmore, US Defence Department's Director of Operational Testing August 2016

1.1 Defence procurement is often characterised by large numbers and opaque decision making. Even by these standards, Australia's planned acquisition of 72 F35A Joint Strike Fighters (JSFs) stands out for its cost and time overruns and lack of a fall-back plan. When even US testing authorities are uncertain whether the aircraft will be fit for service, the basis for the enthusiasm shown by Australian Defence officials documented in this report deserves greater scrutiny.

1.2 **The Greens cannot support the majority recommendations in this report:** it seems entirely likely that Australia will eventually be forced to follow Canada's lead, leave the JSF program and reassess its options rather than simply insisting that there is no plan B.

1.3 The report makes for compelling reading. In particular, Chapter 3 sets out the setbacks and challenges that have beset the JSF since its inception, bringing to light important new breakdowns and challenges in software integration and information security.

1.4 There are meant to be systems in place to prevent debacles such as this from occurring.

1.5 In an episode of ABC Radio National's Background Briefing aired in March 2016, retired Air Commodore Garry Bates explains how the objective procurement process to acquire new aircraft was railroaded:

> Garry Bates: Well, at the end of 2001 we'd just reached the stage of putting out our requests for expressions of interest from the major aircraft manufacturers around the world. Those letters were signed off by me in I believe it was November.
>
> Sarah Dingle: Seven expressions of interest in providing the next fighter jet for Australia came back, and they were locked away unread until the

> submission period finished at the end of January 2002. Garry Bates had left the DMO one month before, but he says those expressions of interest were never analysed.
>
> Garry Bates: There was no comparative analysis of the expressions of interest.
>
> Sarah Dingle: How do you know there was no comparative analysis done of all those responses you received?
>
> Garry Bates: Because I asked and I was told by some of my former colleagues that no, that did not occur.[1]

1.6 In parallel to this tender process, the United States asked Australia to sign up to the System Development and Demonstration Phase of the JSF. The Department of Defence's Capability and Investment Committee considered this offer and recommended that Australia not join up to the JSF program.

1.7 But, despite a live expression of interest process, and despite an internal recommendation to the contrary, six months later Australia got in at the ground level with the JSF in 2002.

1.8 The JSF has since been plagued by a litany of serious problems. The uncovering of these problems, including by the United States' own Government Accountability Office, precipitated the Australian Greens moving for the JSF to be referred for inquiry.

1.9 These issues were covered at length during the course of this inquiry and are detailed in Chapter 3 of the Chair's report. There is a lot of conjecture about the seriousness and intransience of these problems, particularly given the highly technical nature of this issue and the secrecy surrounding the development of the aircraft. As such, the Chair's report rightly concludes that it 'cannot draw definitive conclusions' on the performance capability of the aircraft.

1.10 It is therefore baffling that the Chair's report goes on to state that it is "satisfied" that the JSF will suit Australia's needs. Given the operational capability of the aircraft remains unproven, it is simply impossible to reach this conclusion.

1.11 Inevitably, the problems facing the JSF program have led to delays and cost-overruns. Defence explains this away with the Orwellian term 're-baselining' as a substitute for the more cumbersome 'massive cost overruns, delays, fires, accidents and total loss of confidence.'

1.12 This underscores the fundamental problem with Australia's participation in the JSF Program. The JSF is 'too big to fail' and the Australian Government has steadfastly refused to entertain the idea that the aircraft may never be fit for service. Lockheed Martin profits from the moral hazard and the public will foot the bill.

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1 ABC Radio National, 'Is the Joint Strike Fighter the right plane for Australia?', *Background Briefing*, http://www.abc.net.au/radionational/programs/backgroundbriefing/2016-03-06/7224562#transcript, accessed 12 October 2016.

1.13 The original target date for the first replacement plane to be operational was 2012. The expected date for the first operational JSF is now set for 2020. Australia has already acquired 12 new Boeing EA-18G Growlers to fill the capability gap. Recommendation 1 of the Chair's report acknowledges that Australia still faces a capability gap given the problems with the JSF. Within the paradigm of an obsequious culture, this recommendation is worth acknowledging for its implicit criticism of Defence and the JSF program.

1.14 However, the fundamental problem remains. Australia should follow the example set by the Canadian Government and make preparations to withdraw from the JSF and begin anew a rigorous and objective analysis of the best aircraft suited to Australia's needs.

Recommendation 1

1.15 The Australian Government cancel its contract to acquire the JSF and restart an open tender process to acquire new aircraft.

Senator Scott Ludlam

Additional comments by the Nick Xenophon Team

> **If you don't think about this upfront you're dead in the water at the back end of this.**
>
> Lt. Gen. Christopher Bogdan, United States Air Force

1.1 I commend my colleague, Senator Peter Wish-Wilson, for instigating this inquiry that I co-sponsored—a review into the F-35 Lightning II (Joint Strike Fighter) was essential—given the incredible importance of this project to national security and to the Treasury.

1.2 Whilst I broadly support the recommendations of the Committee, those recommendations do not go far enough, noting the acquisition's importance to Australia.

No Competition

1.3 In March 2002 Defence made a number of recommendations to the Defence Capability Investment Committee (DCIC) which was considering Australia's New Combat Air Capability. That advice recommended, amongst other things, the DCIC:

- agree that sole sourcing to JSF for AIR 6000 now is not appropriate because of concerns about capability, cost and schedule issues with the JSF project; and
- agree that participation in the System Development and Demonstration (SDD) Phase of the Joint Strike Fighter project is not recommended at this time.

1.4 Unfortunately, 7 months later, in October 2002, the then Government approved Australia becoming a partner in the SDD phase of the JSF Program at a cost of US$150 million. At this point in time the competition for the AIR 6000 aircraft was terminated.

1.5 Responses provided to the Committee on what happened between March 2002 and October 2006 were shallow (and will be subject of further inquiry).

1.6 The March 2002 analysis output by Defence was of the highest quality and the most prescient. The project has gone on to have significant capability, cost and schedule problems.

1.7 Australia has entered into one of its most expensive capital procurement projects in a manner that lacks both competition and explanation.

Capability

1.8 The committee received submissions and heard from a number of entities and individuals as to the performance of the F-35.

1.9 The opinions expressed to the committee varied.

1.10 Some entities and individuals, albeit with considerable experience, but without access to classified information, suggested that the aircraft could not and would not compete with aircraft that it might go up against in future conflict.

1.11 Others, albeit with access to classified information but with pecuniary interest or encumbered by considerable long term 'buy in' to the decision to procure the aircraft, suggested the aircraft would meet its expectation and provide the Royal Australian Air Force with a regionally superior fighter aircraft.

1.12 The Australian Strategic Policy Institute was confident that aircraft would meet Australia's needs, but expressed doubt in the ability for the JSF project team to achieve full performance in an acceptable time frame.

1.13 These differing opinions, dependant on perspective, leave little choice but to rely heavily on the analysis of the US Director of Operational Test and Evaluation (DOTE), Dr J. Michael Gilmore. Dr Gilmore is a Presidential appointee confirmed by the United States Senate who serves as the senior advisor to the Secretary of Defense on operational and live fire test and evaluation of Department of Defense weapon systems. Dr Gilmore has access to full information and an obligation to present impartial analysis of the program. He has on a number of occasions expressed considerable concerns about the program. As recently as 9 August 2016 he stated:

> Achieving full Combat Capability with the Joint Strike Fighter is at substantial risk.[1]

1.14 Regard must be had to this statement. He went on further to elaborate:

> While the Air Force recently declared Initial Operational Capability (IOC) with 'basic' Block 3i capabilities, most of the limitations and deficiencies for the F-35A with Block 3i discussed in my FY15 Annual Report and Congressional testimonies remain and will adversely affect mission effectiveness and suitability. In fact, the program is actually not on a path toward success, but instead on a path toward failing to deliver the full Block 3F capabilities for which the Department is paying almost $400 billion by the scheduled end of System Development and Demonstration (SDD) in 2018. If Initial Operational Test and Evaluation (IOT&E) were conducted today on the aircraft in the Block 3i configuration - with which the Air Force recently declared IOC -the system would likely be evaluated as not effective and not suitable across the required mission areas and against currently fielded threats. If used in combat, the F-35 in the Block 3i configuration, which is equivalent in capabilities to Block 2B, will need support to locate and avoid modem threats, acquire targets, and engage formations of enemy fighter aircraft due to outstanding performance deficiencies and limited weapons carriage available (i.e., two bombs and two air-to-air missiles). Unresolved Block 3i deficiencies in fusion, electronic warfare, and weapons employment continue to result in

1 Memorandum for Under Secretary of Defense for Acquisition, Technology and Logistics, Secretary of the Air Force, Chief of Staff of the Air Force. Subject: Achieving Full Combat Capability with the Joint Strike Fighter is at substantial risk – Dr J Michael Gilmore, US Director of Operational Test and Evaluation – 09 August 2016.

> ambiguous threat displays, limited ability to effectively respond to threats, and, in some cases, a requirement for off-board sources to provide accurate coordinates for precision attack. Although the program recently addressed some of the Block 3i deficiencies, many significant deficiencies remain and more are being identified by operational test and fielded units, many of which must be corrected if the program is going to provide the expected 'full warfighting capability' described in the Operational Requirements Document (ORD).[2]

1.15 This summary must be of considerable concern.

Cost

1.16 Acquisition costs in this program have been, and still are, of concern. The F-35 program is the US Defense Department's most expensive. The total program costs to the US have gone from US$233 billion in 2002 to circa US$400 billion today.

1.17 The program was subject to a Technical baseline review in 2010. Since its conclusion cost overruns have been limited, but the August 2016 comments by Dr Gilmore raised new concerns. He stated:

> Despite needing to continue developmental testing at full capacity for at least another year to complete the planned testing of the new capabilities and attempted fixes for the hundreds of remaining deficiencies, the program is already beginning to reduce the number of test personnel and defer required fixes to beyond SDD due to funding constraints.[3]

1.18 He went on further to state:

> It appears as though the program is running out of time and out of money to deliver the required full F-35 combat capability in Block 3F before the completion of SDD … How the program will be able to accomplish the balance of required test points remaining in the time and budget allotted, given historic rates and ongoing personnel reductions, is unclear.[4]

1.19 As a result, the total cost of the program will have to rise again.

1.20 Air Vice-Marshal Deeble indicated at the public hearing that the cost to Australia for the acquisition of 72 aircraft is likely to be $17.1 billion and the cost of through life sustainment will be a further $43 billion. Even a small percentage rise in either of these numbers will be costly.

1.21 With respect to acquisition, whilst Australia is immune from many of the cost overruns in the development phase the final price it will pay for each aircraft is subject to change. If Canada were to pull out of the program, or if the US were to reduce the number of aircraft it ultimately procures, the cost to Australia will rise – with no means at present to mitigate this cost increase.

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2 Ibid.

3 Ibid.

4 Ibid.

1.22 With respect to sustainment, Australia will in effect be a 'captured market' when it comes to sustainment. US Air Force Lt. Gen. Christopher Bogdan, the man who has run the F-35 project for the past 4 years, has indicated in the media that, fifteen years after project initiation, the lack of clear contractual language about ownership of technical data and software code has put the Pentagon in a bind and has limited the government's options on how to maintain, upgrade and manage the Pentagon's largest weapons acquisition:

> I am playing catch-up now every which way I turn when it comes to intellectual property rights in the F-35 program.[5]

1.23 Because contractors and subcontractors have tight control of the intellectual property—from the software to major components and spare parts—the Defense Department has limited authority, for instance, to integrate new systems into the aircraft or do routine maintenance work in government depots. Lt. Gen. Bogdan said further:

> What I'm experiencing is the classic example that if you don't think about this upfront you're dead in the water at the back end of this. We didn't think much about this upfront in the F-35. We didn't write anything into the contract very well.[6]

1.24 The US Air Force C-17 cargo aircraft program offers a cautionary tale. Initially when the program started in the 1990s, the plan was that it would be maintained by the contractor for life, so there was no need to ask for OMIT data:

> Years into the program, the Air Force decided that contractor-provided maintenance was unaffordable, Bogdan said. The service sought to move the work into its own depots, and 'when they started doing that, there was no foundation on IP and data rights. There were mighty struggles. I'm experiencing some of that in the F-35 today.'[7]

Schedule

1.25 I share the concerns of the committee with respect to the F-35's schedule, particularly in light of the recent comments by Dr Gilmore. I agree that Australia must accept that a capability gap is looming.

Recommendations

1.26 Australia has entered into a program without due process and finds itself in a position where, it has suffered from the materialisation of capability, cost and schedule risks that it has identified back in March 2002.

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5 Sandra I. Erwin, 'Intellectual Property Fights Par for the Course in F-35 Program' *National Defense Magazine*, http://www.nationaldefensemagazine.org/blog/Lists/Posts/Post.aspx?ID=2293, accessed 12 October 2016.

6 Ibid.

7 Ibid.

1.27 Australia should follow the Canadian lead with respect to this program. Whilst remaining in the program, Australia should run a competition (including a fly off) to sanity check its decision making. Although the Committee found that none of the alternate aircraft would exactly meet Australia's requirements, neither will an F-35 that will not achieve full combat capability.

Recommendation 1

1.28 Whilst remaining in the F-35 program, Australia should (in cooperation with the Canadians, who are running a competition) re-open and compete for the New Combat Air Capability.

Recommendation 2

1.29 In the event that the F-35 wins the competition:

- **A hedging strategy to mitigate the capability gap that could result from further schedule slippage, as recommended by the Committee, should be sought.**
- **A fixed price contract for the aircraft should be negotiated with liquidated damages to be passed through the US Government to Lockheed Martin in the event that the company does not deliver in accordance with contracted performance or schedule.**
- **The Department of Defence develop a sovereign industrial capability strategy for the F-35 to ensure that Australian Aircraft can be maintained and supported without undue reliance on other nations. This strategy should include the negotiation of intellectual property rights (in similar scope and terms to that which we have for Collins Class submarine sustainment purposes) with Lockheed Martin, prior to any further purchases, which would facilitate such a sovereign capability.**
- **The government endeavour to establish Australia as the Asia-Pacific maintenance and sustainment hub for the F-35.**

Senator Nick Xenophon

Appendix 1

Submissions

1. Mr Chris Mills

1.1. Supplementary Submission

1.2. Supplementary Submission

1.3. Supplementary Submission

1.4. Supplementary Submission

2. Mr Michael Price

3. Dr Jai Galliott

4. WGCDR Anthony Wilkinson (Rtd)

5. Dr Keith Joiner

6. Mr Daniel Nowlan

6.1. Supplementary Submission

6.2. Supplementary Submission

6.3. Supplementary Submission

7. Name Withheld

8. Mr David Archibald

9. Air Power Australia

9.1. Supplementary Submission

9.2. Supplementary Submission

9.3. Supplementary Submission

10. Mr Steve Weathers

11. Mr John Peake

12. Mr Marcus Kollakides

12.1. Supplementary Submission

12.2. Supplementary Submission

12.3. Supplementary Submission

12.4. Supplementary Submission

13. Name Withheld

14. Name Withheld

15. Mrs Beverley Male

16. Mr Donald Bacon

17. The Sir Richard Williams Foundation

18. Chemring Australia Pty Ltd

19. Mr Eric Palmer

20. Mr Alan Williams

21. Professor Mark Beeson

22. AIRCDRE Ray Perry (Rtd)

23. Marand

24. DMTC Ltd

25. Mr Peter Larard

26. Quickstep Holdings Limited

27. Mr E.J. Bushell

28. Mr Robert Charette

29. Mr Garry Bates

30. Mrs Christine Sykes

31. Lovitt Technologies Australia and Electromold Australia

32. Heat Treatment Australia

33. Mr Scott Perdue

34. Mr Robert Gottliebsen

35. Lt.Col Anker Sorensen (Rtd)

36. Mr Peter Goon

36.1. Supplementary Submission

37. Mr Michael Wunderlich

38. Mr Geoffrey de Looze

39. Levett Engineering

40. Name Withheld

41. Northrop Grumman Australia

42. Mr James Hicks

43. Ferra Engineering Australia

44. Mr Steven Jones

45. TAE Gas Turbines Pty Ltd

46. Lockheed Martin

47. Australian Strategic Policy Institute

48. Mr Jonathan Whitty

49. BAE Systems Australia

50. Medical Association for Prevention of War

51. Mr John Donahoo

51.1. Supplementary Submission

52. Mr Greg Jeanes

53. Mr Roger Jennings

54. Mr Erik Peacock

55. Department of Defence

56. United States of America Department of Defense

57. Mr Errol Coultis

Appendix 2

Tabled documents, answers to questions on notice and additional information

Tabled documents

1. Opening statement, tabled by Mr Peter Goon at public hearing, 22 March 2016

2. On Air Power Australia: A Brief Introduction, tabled by Mr Peter Goon at public hearing, 22 March 2016

3. 24 Million Software Lines of Code: What does this statement really mean?, tabled by Mr Peter Goon at public hearing, 22 March 2016

4. Note on Analysing the Focus, Basis and Methods of Argumentation in Submission to Senate Inquiry into the JSF, tabled by Mr Peter Goon at public hearing, 22 March 2016

5. Opening statement, tabled by Dr Andrew Davies at public hearing, 22 March 2016

6. Opening statement, tabled by Dr Keith Joiner at public hearing, 22 March 2016

7. Opening statement, tabled by Mr Raydon Gates at public hearing, 22 March 2016

8. P. Goon, 'ZOCT Table', tabled by Senator Nick Xenophon at public hearing, 22 March 2016

Answers to questions on notice

1. Australian Strategic Policy Institute - Answer to question on notice from public hearing held on 22 March 2016 (received 22 March 2016)

2. Defence Materials Technology Centre - Answers to questions on notice from public hearing held on 22 March 2016 (received 7 April 2016)

3. Northrop Grumman - Answers to questions on notice from public hearing held on 22 March 2016 (received 8 April 2016)

4. Sir Richard Williams Foundation - Answers to questions on notice from public hearing held on 22 March 2016 (received 14 April 2016)

5. Lockheed Martin - Answers to questions on notice from public hearing held on 22 March 2016 (received 18 April 2016)

6. Department of Defence - Answer to question on notice from public hearing held on 22 March 2016 (received 26 April 2016)

7. Australian Strategic Policy Institute - Answer to written question on notice from public hearing held on 22 March 2016 (received 27 April 2016)

8. Department of Defence - Answers to questions on notice from public hearing held on 22 March 2016 (received 4 May 2016)

9. Department of Defence - Answers to questions on notice from public hearing held on 22 March 2016 (received 4 May 2016)

10. Department of Defence - Answer to question on notice from public hearing held on 22 March 2016 (received 30 September 2016)

Additional information

1. United States of America Office of the Director, Operational Test and Evaluation (DOT&E), 'F-35 Joint Strike Fighter (JSF)' in FY2015 Annual Report, (received 2 February 2016)

2. Compendium of DOT&E Annual Reports: F-22A Raptor Air Dominance Fighter Program, compiled and provided by Air Power Australia, (received 10 February 2016)

3. Compendium of DOT&E Annual Reports: F-35 JSF Program, compiled and provided by Air Power Australia, (received 10 February 2016)

4. W.D. Hartung, 'Promising the Sky: Pork Barrel Politics and the F-35 Combat Aircraft', International Policy Report, Center for International Policy, January 2014, provided by Mr Chris Mills (received 10 March 2016)

5. ABC - Radio National - Transcript of 'Is the Joint Strike Fighter the right plane for Australia?', broadcast 6 March 2016, provided by Mr Chris Mills (received 10 March 2016)

6. Alan Williams, 'Opening comments to the Canadian Standing Committee on National Defence', 7 October 2010, provided by Mr Alan Williams, (received 11 March 2016)

7. Alan Williams, 'Flying solo', canada.com, 28 October 2013, provided by Mr Alan Williams, (received 11 March 2016)

8. Don Martin, 'Harper facing dogfight over fighter jet deal' National Post, 7 October 2016, provided by Mr Alan Williams, (received 11 March 2016)

9. Jeffrey Simpson, 'F-35 fiasco knocks Conservative spin off axis', The Globe and Mail, 8 December 2012, provided by Mr Alan Williams, (received 11 March 2016)

10. Michael Den Tandt, 'Heads should roll for F-35 fiasco', Montreal Gazette, 3 April 2012, provided by Mr Alan Williams (received 11 March 2016)

Appendix 3

Public hearing and witnesses

Tuesday 22 March 2016

Air Power Australia

Mr Peter Goon, Head of Test & Evaluation

Mr Christopher Mills, Member

Mr Alan Williams, Private Capacity

The Sir Richard Williams Foundation

Air Marshal Errol J. McCormack AO (Retd), Chair

Air Marshal Geoff Brown AO (Retd), Deputy Chairman

Australian Strategic Policy Institute

Dr Andrew Davies, Director of Research/Senior Analyst – Defence Capability

Dr Keith Joiner, Private Capacity

Marand Precision Engineering Pty Ltd

Mr Rohan Stocker, Chief Executive Officer

Quickstep Holding Limited

Mr Tony Quick, Chairman

Mr Carl de Koning, Executive General Manager, Business Development & External Relations

Heat Treatment Australia

Ms Karen Stanton, Director – Strategy & Corporate

Northrop Grumman Australia

Mr Ian Irving, Chief Executive

BAE Systems Australia

Mr Andrew Gresham, F-35 Campaign Manager

Defence Materials Technology Centre

Dr Mark Hodge, Chief Executive Officer

Lockheed Martin

Mr Raydon Gates, Chief Executive

Mr Jeff Babione, Executive Vice President and General Manager of F-35 Lightening II Program

Mr Gary North, Vice President, Customer Requirements, Aeronautics

Department of Defence

Air Marshal Leo Davies, Chief of Air Force

Air Vice-Marshal Leigh Gordon, Program Manager, Joint Strike Fighter

Air Vice-Marshal Chris Deeble (Retd), Program Manager, Joint Strike Fighter

Dr Todd Mansell, Acting Chief Defence Scientist

Mr Kim Gillis, Deputy Secretary, Capability Acquisition & Sustainment

Appendix 4

Air Power Australia's ZOCT Table

AIR POWER AUSTRALIA

ZOCT TABLE:

IS THE JSF REALLY A FIFTH (5TH) GENERATION FIGHTER?

Senate Estimates, 02 & 03 June 2014

Senator CONROY: …..You have been very emphatic that ***generation five*** against ***generation four*** is ***not a contest***. Other than the countries you have named, are there any other countries that you are aware of who have developed the fifth-generation fighter capacity at this stage?
Air Marshal Brown: The Chinese have two aircraft in development and the Russians have an aircraft as well. But the way I would characterise their development is that the JSF flew two prototypes probably 10 to 12 years ago, and that is about where both of those countries are at the moment. There is a fair bit of work to be done on all three aircraft. I do not believe that any of those three aircraft have the same stealth characteristics of an F-35.
Air Marshal Brown: I think it is on two bases: probably stealth technology, the inability to have low probability of detection on electronic emissions, and engine technology. This is where both the Russians and the Chinese are significantly behind Western engines.
Air Marshal Brown: No, I think that they *[the Russians]* would like to see it *[Su-50]* as a pure fighter aircraft. At the moment I am not aware of any air-to-ground munitions that it is able to drop.
Air Marshal Brown: One [Chengdu J-20] is probably a pure fighter. I would classify it more as an interceptor. The other one [Shenyang J-31] is a little bit more like an F35.
Some Data and Facts: ***Beliefs, feelings and conjecture are negotiable; data and facts are not!*** (1) Two X-35's flew in 2000; were Dem/Val proof-of-concept test articles; not representative of F-35. (2) Sukhoi contracted to design/develop the Su-50 in 2002, same year JSF SDD contract was signed. (3) Reports of Chengdu J-20 scaled and full scale test articles flown circa 2006. (4) Quality of finish of J-20 noted back in 2011 as being at level of pre-production prototype. (5) J-20 has equivalent of 4 x large weapon bays + 6 x external store wing stations. J-20 Serial No 2021 is first production aircraft. (6) Su-50 (T-50 PAK-FA) has similar weapon/store carrying configuration; is equipped with new A-A and A-G weapons as well as weapons/stores from extant inventory. Su-50 in full scaled production by 2017. (7) Unlike the F-35A JSF, the J-31 is a twin-engined, large finned, LO 'stealthy' design aircraft with shaping features more akin to those of the F-22A Raptor. Likely will also be carrier suitable.

Annex A: ZOCT (*Zero-One Comparative Technique*) Table

Is the JSF Really a Fifth Generation Fighter?

(Updated: 13 January 2016)

5th Generation Air Combat Fighter Capability Metrics	Operating Post 4th Gen Air Combat Capability Aircraft				Current Threat	NACC Aircraft
	F-22A Raptor	T-50 PAK-FA	Chengdu J-20	F-35A JSF Lightning II	Gen 4++ Su-35S	Super Hornet F/A-18F
	USA	Russia	China	Internat'l	Russia	USA
Super Cruise, Mach 1.5 or greater in MILPWR	Yes (0)	Yes (0)	Yes (0)	No (-1)	Yes (0)	No (-1)
Super Agility Supersonic / Subsonic	Yes (0)	Extreme Plus (+1)	Extreme (+1)	Neither (-1)	Extreme (+1)	Neither (-1)
Very High Specific Excess Power - P_s	Yes (0)	Yes (0)	Yes (0)	No (-1)	Yes (0)	No (-1)
Thrust Vectoring Control - TVC 2-D	Yes 2-D (0)	Yes 3-D (+1)	Accommodated	No (-1)	Yes 3-D (+1)	No (-1)
Advanced Highly Integrated Avionics	Yes (0)	Yes (0)	Yes (0)	Yes (0)	Yes (0)	Yes (0)
Electronically Steered Array (ESA) Radar	High Power Aperture (+1)	High Power Aperture (+1)	Yes (0)	Medium Power Aperture (0)	High Power Aperture (+1)	Medium Power Aperture (0)
Additional ESA Apertures	FFBNW (0)	Yes + L Band (+1)	Insufficient Data	No (-1)	Yes + L Band (+1)	No (-1)
High Situational Awareness (SA) - Onboard/Offboard	Yes (0)	Yes (0)	Yes (0)	Yes (0)	Yes (0)	Yes (0)
Large Supersonic Weapons Delivery Envelope	Yes (0)	Yes (0)	Highly Probable	Limited (Slab Doors / Toed-In SS) (-1)	Yes (0)	Limited (Toed-Out Carriage) (-1)
Large Thrust to Weight Multi-Engine Thrust Growth	Yes 2 Engines Large Growth (0)	Yes 2 Engines Large Growth (0)	Yes 2 Engines Large Growth (0)	Middling T/W Single Engine Little Growth (-1)	Yes 2 Engines Large Growth (0)	Middling T/W Little Growth (-1)
High Combat Ceiling Loiter/Operate (> 7 deg /sec sustained @ 30 kft)	Yes, > 55 kft Yes (0)	Yes, > 60 kft Yes (0)	Yes, > 50 kft Yes (0)	No, < 45 kft No (-1)	Yes, > 55 kft Yes (0)	No, < 45 kft No (-1)
Very Low Observable (VLO) RF Stealth	All Aspect Wideband (+1)	Yes but Partial (0)	Yes but Partial (0)	Yes but Partial (0)	No (-1)	No (-1)
Good Non RF Low Observables	Yes (0)	Yes (0)	Yes (0)	No VOVS/WVE (-1)	Yes (0)	Yes (0)
Large Internal Usable Fuel Load / Persistence (klbs)	Yes >18k lbs PLUS thermal cooling fuel (0)	Yes, ~23k lbs (+1)	Yes, ~25k lbs (+1)	18.2k lbs MINUS thermal cooling fuel (0)	Yes >23k lbs (+1)	No <13.5k lbs (-1)
Internal Weapon Carriage Hard Point Stations	Yes 6 + 2 (0)	Yes 6+2 (0)	Yes 6 + 2 (0)	Yes 4 (0)	Partial (Tunnel Pod) 2 - 4 (-1)	No (-1)
ZOCT Scoring by 5th Gen Metrics	+2	+5	+2	-9	+3	-11

ZOCT Scoring:

-1 Does not meet 5th Gen Metric
0 Meets 5th Gen Metric
+1 Meets 5th Gen Metric with Enhancing Characteristic/s

Notes:
(1) Though outside scope of this ZOCT Table, suitable and effective A-A/A-G weapons are crucial metrics of the overall air combat capability.

(2) Price is not a 5th Gen metric. Though, when it comes to comparative/competitive pricing of any aircraft let alone 5th Gen air combat aircraft, the fundamental tenets of any such analysis include:

a. Compare the 'total price', not some subordinate 'cost' (e.g. unit recurring flyaway cost).
b. Compare in US$'s applicable at the time of purchase, cogniscant of purchasing power parity (PPP) and the influence this has on comparative/competitive pricing outcomes.
c. Match 'price' to 'capabilities'- the price being total payment at time of purchase for what is needed.
d. Beware of 'order splitting', 'price splitting' and other techniques used to spread the price over various activities other than the acquisition. For example, in relation to the F-35 JSF, '*the never ending price*' baked into the designs.

Summary of Observations

a. Relative to most Fourth (4th) and evolved Third (3rd) Generation air combat fighter aircraft, Fifth Generation Fighters are large, twin engined quite stealthy (VLO-RF/LO-Other) designs with Super to Extreme Agility over the aircraft's total flight envelope (from post-stall to high supersonic), capable of super-cruising at up to Mach 1.5 or higher, with sufficient specific exess power (Ps) for both BVR and WVR engagements, inherent survivability and persistence (both weapons and fuel), and the ability along with the sensors and information processing and networking capabilities to provide their pilots and other operators with high levels of precise and accurate situational awareness in real time.

b. In terms of Fifth (5th) Generation Air Combat Fighter Capability Metrics, the F-35A JSF scores poorly, rating only slightly ahead of the F/A-18F Super Hornet - a Gen 4.5 design - yet well behind the Su-35S - the Russian Gen 4++ design.

Conclusions

1. The F-35A JSF's shortfalls in most of the cardinal Fifth (5th) Generation capabilities do not warrant this aircraft being called a Fifth (5th) Generation Fighter Aircraft, as defined by the marketplace.

2. This should come as no surprise to anyone familiar with the JSF JORD and its origins which sought a medium stealth fighter (MSF) with a single engine and relaxed aero-propulsive performance, both for reasons of affordability, and commonality of design with the STOVL F-35B variant being the baseline design for all three JSF design variants.