

THE SIR RICHARD WILLIAMS FOUNDATION INC

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Foreign Affairs, Defence and Trade Committee
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Inquiry into the planned acquisition of the F-35 Lighting II (Joint Strike Fighter)

Please find attached a submission to the Inquiry from the Sir Richard Williams Foundation.

I would welcome the opportunity to discuss the submission with the Committee or individual Members.

E.J. McCormack
Chair

Attachment: Senate Sub-Committee Submission – F-35 Joint Strike Fighter

The Sir Richard Williams Foundation

Senate Sub-Committee Submission

F-35 Joint Strike Fighter

Executive Summary

The Sir Richard Williams Foundation, in close consultation with the Department of Defence, Defence industry, academia and overseas experts, has recently conducted three seminars exploring the challenges and opportunities afforded by the introduction of the F-35's air combat capabilities. Two further seminars are planned in 2016 on the F-35's role in Air/Land and Air/Sea operations.

Through its research and analysis, the Foundation has concluded that the F-35 is the only viable candidate that will meet the full range of Australia's air superiority needs in 2025 and beyond through the provision of 5th generation air combat capability. The only other 5th generation aircraft, the F-22, is not a viable option as it does not provide the true multi-role air combat capability Australia needs, its production line has closed and Congress has ruled that it would never be exported. Even if these issues could be overcome, the delivery schedule and costs would be prohibitive for a small production run.

A strong benefit of Australia's partnership in the F-35 Program is Australian industry's involvement in the production, sustainment and follow-on development of the F-35 Air System. The Program has recognised the benefits of a diverse and vigorous global supply chain and has deliberately integrated Australia's industry base into that supply chain.

The F-35 presents a whole new way of doing business for the ADF and will require a number of key enabler capabilities in order to maximise its potential to make not just the RAAF but key elements of the whole ADF more effective in the future battlespace.

The F-35 should not be considered simply as a replacement aircraft for the Classic Hornet or Super Hornet as this would undermine its real capability as generational leap in not just technology but warfighting more broadly. The F-35 does not replace anything; it is unique, it is revolutionary, and represents a generational change in what tactical platforms can do and the strategic effect they can generate. It is an introduction to a different way of thinking about operations, land, sea and air. Air Force's Plan Jericho has the Foundation's strong support as it will be the vehicle for fully exploiting the largest technological upgrade in Air Force's history including the F-35.

Foundation Overview

Named after the founder of the Royal Australian Air Force, the Sir Richard Williams Foundation is an independent research organisation whose purpose is to promote the development and effective implementation of national security and defence policies as they impact on Australia's ability to generate air power appropriate to its unique geopolitical environment and values.

The Foundation aims to strengthen Australia's national security by advocating for forward-looking policies that take full advantage of the potential for air power to shape and influence regional security; and by promoting constructive debate regarding the implementation of such policies.

Membership of the Foundation is open to anyone interested in Australia's ability to generate air power. Current membership includes people with extensive and senior experience in all three Services and Defence industry.

More information on the Foundation can be found at <http://www.williamsfoundation.org.au>

Foundation Seminars on the F-35 and Future Air Operations

Since March 2014 the Foundation has conducted three seminars in Canberra on the F-35 and the future of air combat operations:

1. Air Combat Operations 2025 and Beyond
2. Battle Space Awareness – The Joint Edge
3. Plan Jericho – Implementation

Seminar reports can be found [here](#).

Plan Jericho is the Air Force's response to the largest technological upgrade in its history (F-35, EA-18G Growler, P-8A Poseidon and E-7A Wedgetail). Air Force's people, operating concepts, training, systems and sustainment need to be transformed so that these new capabilities are exploited to realise their full potential.

Plan Jericho also involves Air Force working with Navy and Army to ensure a networked future joint force. With this in mind, the Foundation is conducting two more seminars in the F-35 studies series in 2016 on "Air/Land Operations" and "Air/Sea Operations".

Air Power

Since its inception as a military tool nearly 100 years ago, air power has played a crucial role in every conflict in which Australia has been involved. Air power is now more critical to Australia's national security than at any time in the past.

An Air Force must be capable of responding to current events and postured to meet future challenges. As a middle power, Australia must also be able to help shape its security environment.

Air Forces have four enduring core roles. Firstly, they move things through the air - Air Mobility. Secondly they observe things from the air and ground - Intelligence, Surveillance and Reconnaissance (ISR). Thirdly they effect things on the ground and sea from the air - Strike. But the most important thing that an air force brings to the fight is the ability to control the air domain – Control of the Air.

Without control of the air, all land, sea and air operations remain at substantial risk. The ability to ensure freedom from air attack enables land, air and sea forces the freedom to manoeuvre as well as the freedom to attack.

Planning to fight the last war is a fatal mistake for any nation.

The RAAF therefore needs an air combat system that delivers on its prime responsibility of controlling the air and the F-35 provides the capability to succeed in the air across the full spectrum of conflict. However, the F-35 is a true multi-role fighter and can also deliver on another two of air power's enduring roles: contested ISR and Strike. This multi-role capability is essential for a relatively small air force.

The best aircraft is not the only ingredient. Numbers matter - capacity is just as important to future security. Control of the air is a numbers hungry operation but it is critical to the Joint campaign. When maintenance requirements, upgrade programs, training and attrition are taken into account, along with other air combat roles, the number of aircraft available will always present a challenge for a country the size of Australia. For Australia, anything less than 100 F-35s would severely limit the options available to Government to meet its air combat needs.

Do Nothing is not an Option

Making do with the present fighter fleet of 71 F/A-18A/B (Classic Hornets), 24 F/A-18F (Super Hornets) and 12 E/F-18G (Growlers) aircraft is not an option as it would expose the ADF to two areas of significant risk, namely aircraft life-of-type and capability against future threats.

The RAAF's F/A-18A/B aircraft were delivered in 1985 with a notional life of 6,000 flying hours. Some of the fleet has already passed that milestone through the careful management of fatigue accrual and a series of upgrades to the airframe. 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.

The F-35 is the Best Choice

Australia's air combat needs have been derived through extensive and detailed analysis of the future threat environment and the full range of roles our future air combat capability needs to conduct:

- equally capable of defeating airborne threats, prosecuting attacks against surface targets on the land and sea
- able to support Australia's land and maritime force
- able to operate against increasingly capable threat systems that are highly effective against combat aircraft that do not have the advantages of the fifth-generation F-35

The F-35 offers the following advantages over non 5th generation aircraft:

- Combination of very low observability and advanced integrated avionic systems
- Integrated sensors and the ability to fuse data to generate unparalleled situational awareness
- Able to take data from other platforms to enhance situational awareness and share this not just with other F-35s but also other capabilities in the battle space

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.

The F-35 capability will also enhance the effectiveness of other ADF elements such as the Airborne Early Warning and Control platforms and the Air Warfare Destroyer as well as being able to provide precision fires to ground forces.

In the context of Plan Jericho for the delivery of a fully integrated and networked force, the F-35 is both the cornerstone and catalyst for change in the ADF.

Alternatives to the F-35

The Super Hornet, F-16 Block 60, F-15, Typhoon Euro Fighter, Rafael and Gripen were all analysed and considered by Australia as options for its future air combat capability but none of them were able to meet all of Australia's requirements. All were vulnerable to advanced threats and they did not provide the same opportunity to be continually upgraded to meet these evolving threats.

The F-22 was also evaluated by the Air Force for its abilities to meet Australia's future air combat needs. While undoubtedly the world's best air dominance fighter, the F-22 could not meet all of Australia's multi-role requirements necessary to deliver the integrated air combat capability and support to the joint force.

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.

Acquisition of Eastern Block aircraft were also considered but would come with prohibitive restrictions in terms of interoperability for combined operations.

F-35 Program

Australia first invested in the F-35 Program in 2002 along with the other partner nations namely the US, UK, Canada, Italy, the Netherlands, Turkey, Denmark and Norway. Since then, other nations such as Israel, South Korea and Japan have also concluded that the F-35 is the best choice for their air capability needs. Not all of these countries – including the world's pre-eminent fighter forces - can be wrong.

There is no question that the Program has experienced considerable schedule delays and cost increases since it was first approved. Development cost increases, however, have not been passed on to partner countries and Australia has always maintained considerable levels of contingency to cover increases in acquisition costs.

Since the Program was re-baselined in 2012, it has remained on budget, on schedule and meeting capability parameters. Australia still retains some margin to cater for any further schedule slippage in the Program should it occur.

For a Program of this complexity, test and evaluation (T&E) inevitably will identify issues that need to be resolved. Australia is leveraging off US T&E while its own T&E efforts are focused on integrating the F-35 with other ADF capabilities. The progressive resolution of these issues is clearly demonstrated by the fact that around 200 F-35s will be in operational service by end 2016.

F-35 Industry Involvement

The F-35 Program aims to promote new, as well as continued, involvement of the industries from the partner nations in the system development, production, sustainment and follow-on development of the F-35 Air System. The Program has recognised the benefits of a

diverse and vigorous global supply chain and has deliberately engaged with and invested in the partner nations' industry base.

A number of Australian companies have already shown they can provide best value to the F-35 Program. As at December 2015, Australian companies had secured US\$554 million in F-35 contracts that have brought hundreds of new jobs, new industry capabilities and new advanced technology. Contracts range from treated raw materials to high-end manufacturing of components and sub-assemblies, ground equipment, software development and production of sensitive technologies. In addition, a number of Australian companies in the F-35 Program have won non-Program work because of their proven capabilities in these new technologies (e.g. Quickstep, supplier of F-35 external surface panels, has been awarded a sole global contract by Lockheed Martin for a number of C130 parts).

The forecast contract value over time for Australian Industry in design and production will increase to US\$2 billion by 2023. Australian companies are expected to be fully embedded in the global supply chain by 2023, once Australia's full aircraft order is complete. Production of the F-35 is expected to continue until 2035.

The Australian Department of Defence is committed to ensuring that Australian industry is embedded in ongoing global continuous improvement activities for the F-35. These opportunities would not have existed for an off-the-shelf, current generation, short production run aircraft.

Air Combat Operations – 2025 and Beyond

On 11 March 2014, the Foundation conducted a seminar exploring the challenges and opportunities afforded by the introduction of 5th generation air combat capabilities. Themes explored included:

- The future Asia/Pacific security environment
- Future technology advances and challenges
- How the US Marines are approaching the challenges and opportunities of integrating 5th generation capabilities with the legacy force
- Consideration on how the RAAF will approach the transition to, and integration of, 5th generation airpower capabilities

The seminar sought to identify the many opportunities and complex issues that 5th generation air combat capabilities will bring to the RAAF and to those of Australia's allies and regional partners.

An explanation of 5th generation aircraft can be found at *Appendix 1*.

The Foundation's seminar brought together a high calibre mix of current and recent past leaders from Defence, industry, academia, the scientific community and current and future capability operators. They discussed the emerging trends in air combat operations and geopolitical influences, and how these may inform future force structures and postures in our region and further afield, and the way a 5th generation platform will be operated. The

seminar in particular set out to explore ways of preventing old methods constraining the game-changing capabilities that the F-35 offers and whether current education, training and logistics systems will be able to accommodate the introduction of a 5th generation capability.

Speakers at the seminar shared their views and understandings of the current and near future status of the RAAF and global air forces; of the threats starting to enter service in the region; of their professional experiences in operating 5th generation combat aircraft; and the comparisons of the capabilities offered by 5th generation platforms/systems compared to legacy platforms/systems. They also spoke about the current and near-future geopolitical situation in the Asia-Pacific region; about the rise of China and where its current and future ambitions may lie; and of the current status of the F-35 Program.

The long lead times involved in developing and fielding complex systems such as modern air combat systems require decisions now on what we will field in 2025. It is also important to recognise that the way the F-35 will be employed will likely evolve over time and will change with experience. Simply acquiring the F-35, as with any aircraft acquisition, will not deliver an airpower advantage. It must be employed not as a stand-alone capability but as an essential enabling element in an integrated system-of-systems.

Fifth generation fighters like the F-22 and F-35 are an essential part of an “ecosystem” that offer great scope for innovation with the right operators. But the ecosystem has to be integrated, because the more people who can get inside that ecosystem, the more intelligent the communications become, the better enabled everyone is. 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).

What makes the F-22 and F-35 special is not just that they have unmatched sensors and stealth, but that they make everyone else in the ecosystem more capable. A good analogy for a small force with limited resources such as the RAAF is the fact that the USAF only received some 180 F-22s out of a planned force of up to 750, and thus had to “come to grips” with integrating the F-22 into its force to make its legacy aircraft better.

The F-35 should not be treated just as a replacement aircraft for the Hornet or Super Hornet as this would undermine its real capability. It does not replace anything, it is unique, it is revolutionary, and it is in a world never before defined by what tactical platforms can do.

This is a message that, unfortunately, has failed to gain traction in the public arena and among many air power commentators where the debate has consistently been reduced to the lowest common denominator whenever the acquisition of a new combat aircraft is announced. The Super Hornet was erroneously touted as a replacement for the F-111, and more recently the potentially game-changing P-8 Poseidon and MQ-4C Triton Unmanned Aerial System have been seen by some as merely P-3 Orion replacements. While all of these

aircraft will certainly take over the missions performed by their predecessors, they will also bring many new capabilities to the entire ADF.

During its early development, the F-35 was touted as a replacement for nine different aircraft types currently operated by the partner nations, with all the associated operating cost efficiencies and commonality benefits that would bring. In hindsight, a massive opportunity was missed to also explain the implications of the new capabilities the F-35 would bring, not just in an air combat context but when exploited fully, to a nation's entire force structure.

Step Change

The F-35 provides a step change in capability through the aircraft's low -observability, improved situational awareness from advanced sensors, Low Probability of Intercept (LPI) and Low Probability of Detection (LPD) communications, and other advanced systems that differentiate it from its predecessors.

To emphasise the rate of change in sensors and other systems, the classic Hornet that was developed in the 1970s is a very different aircraft today to the one the RAAF initially acquired. In the last decade the Hornet has undergone a massive mid-life upgrade program that has seen it equipped with a more capable APG-73 radar, Link 16 and ARC-210 communications suite, enhanced cockpit displays, an advanced electronic warfare suite, a helmet mounted cueing system with new high PK active and high off-bore sight air-to-air missiles, and precision-guided and stand-off air-to-surface weapons.

Despite the advances that have made the classic Hornet one of the best 4th generation aircraft in operation, the aircraft is still very limited when compared to the F-35. It still has mechanically scanned radar that needs to be "driven by the pilot", which restricts the number of targets it can detect and track, and Link 16 network limitations require compromises when everyone wants to use it.

The Hornet is not low-observable in any way, its mission computers are at 100 per cent capacity, and its sensor performance is very sensitive to the operator's skill levels. Sensor fusion for a Hornet pilot essentially means looking at multiple displays, each one displaying a different sensor picture which may not be up-to-date due to Link 16 limitations, and often having to make a best-guess decision based on limited situational awareness.

The Super Hornet has brought improvements through its electronically scanned Advanced Electronically Scanned Array radar, integrated electronic warfare features, some observability reduction enhancements, an advanced mission computer and better sensor fusion which provides a greater ability to manage complex EW and targeting. These improvements mean that the Super Hornet is survivable and upgradeable into the 2020s. However, the Super Hornet is still limited by being confined to a Link 16 network that isn't Low Probability of Intercept, and, despite the better sensors, the lack of real sensor fusion adds a layer of complexity that can result in task saturation, although this is to some extent reduced through the use of a two-person crew. Notwithstanding these improvements, it remains challenging for Super Hornet crew to determine what the best way is to track an adversary and maintain situational awareness against advanced threats.

By comparison, 5th generation aircraft are built from the ground up to optimise the capabilities of their integrated avionics. All the sensors built into the aircraft are controlled by a central core processor, which means the pilot doesn't need to manipulate them. The cockpit displays provide a fully fused picture based on all the information available from on-board and off-board sensors leading to unprecedented integration of the pilot with the aircraft.

Data fusion is the "key enabler" for 5th generation aircraft. Sensors require little or no manipulation freeing up a significant amount of brain space for the pilot. All relevant information is presented fully synchronised, not just for that aircraft but also for other F-35 aircraft flying in formation as well as other aircraft in the network.

The data fusion offered by 5th generation platforms represents a decisive advance in the breadth and depth of information that can be used to achieve dominant situational awareness. It is unlikely that we fully understand what that breadth and depth will allow pilots to do yet, due to the vast differences to the capabilities offered by legacy platforms. It is not just a matter of being able to function with a wide array of information – the F-35 has the ability, coupled with its inherent agility, to operate effectively in whatever spectrum it needs to be (e.g. radio frequencies, infrared (IR), laser or electro optical).

Stealth

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.

Interoperability

To fully realise the potential that the F-35 offers it needs to be fully integrated into the ADF's force structure and not employed as a stand-alone 5th generation capability. The F-35 and its 5th generation capabilities will make many of the ADF's other capabilities more effective. Even better than four F-35s will be four F-35s flying with four Super Hornets. The situational awareness the F-35 provides to its pilot in a fight can be shared not only with other F-35 and other combat aircraft, but with AEW&C, Growler, AWD and LHD surface ships, with ground forces, and with the command and control (C2) network via Vigilare (Air Force's integrated ground-based air defence command and control system). This shared situation awareness will help to provide a more complete and timely 'big picture' of the battle space.

Battle space awareness requires a wide range of joint capabilities. Fortunately for the ADF, many of those capabilities are already in place or on the way, but are yet to be fully integrated to achieve the 'joint' part of the equation. The achievement of battle space awareness and information superiority is no straightforward undertaking. It depends heavily on substantial capabilities in information management and processing which rely on the so-called 'glue' projects needed to create a truly integrated ADF. There are also substantial advancements needed in the way the ADF manages its people, its training, its doctrine and its governance to extract the most from its 5th generation capabilities.

The work being done by the First Principles Review to truly deliver One Defence is ongoing and the F-35 is part of that wider effort.

Training

The old fighter pilot mantra of "speed is life; more is better" is no longer the primary consideration in air combat. Instead the new mantra is "information is life; more is better". Information is now the most precious commodity a combat aircraft can provide. What this means for future generations of fighter pilots and how to train to the new mantra is one of the biggest challenges facing the ADF and a key consideration of Plan Jericho.

The burden on the pilot inside the F-35 cockpit is going to change dramatically. The expectation of a wingman with 200-hours of fighter experience in the F-35 will be exponentially greater than that of a 200-hour wingman in a legacy fighter. The ADF's training system will need to recognise this and adapt in order to get pilots up to speed quicker.

Whilst the fundamentals of the ADF's current and planned training systems are sound, low-hour wingmen will need to be trained as tacticians from an earlier point in the training process than is currently done. The legacy aircraft pilot-driven systems mean it takes time and practice to manage information and to upgrade from wingmen to flight leader, to flight commander, to instructor pilot, due to system management and task saturation.

But with much of the system management already taken care of in the F-35, the new aircraft's systems are significantly less sensitive to the experience or lack thereof of the aircrew.

The transition to the F-35 will be no more difficult than the current transition aircrew make to the Hornet and Super Hornet. The F-35 is electronically more complicated but the information is assimilated and fused for the aircrew such that they can concentrate on fighting the enemy rather than controlling the systems and sensors in the aircraft to build situational awareness and make decisions. The ADF will need to observe and adjust as it learns more from the first F-35 aircrews and find ways to optimise the way it trains ab initio students for their F-35 conversion.

Security

While the F-35 brings new and advanced capabilities to the ADF, it is understandably also encumbered with a greater burden of security and information assurance. To this end, the

ADF will need to re-think how it manages information in the future. For example, advanced sensors come with some caveats on identifying how or where the information was obtained, so the right security environment will need to be created. The sharing of high fidelity situational awareness will need a greater emphasis on making sure all the people who need access to that information have the right security clearances to access it.

Air Force took its first tentative steps down this path when it acquired the Super Hornets in 2007. New compartmentalised headquarters facilities were required in order to deal with the security requirements associated with operating aircraft with the Super Hornet's LO materials, advanced sensors, and other capabilities. In a sense, the Super Hornet has provided an insight into what the ADF will need to do in order to accommodate the security aspects of the F-35, albeit on a much larger scale.

Similar considerations have been applied to high-end capabilities such as JORN, Vigilare, and the E-7 Wedgetail AEW&C, and will no doubt be applied to the P-8 and MQ-4C Triton when they enter service. Similarly, the capabilities provided by Navy's new Aegis radar-equipped destroyers will require a greater emphasis on security and information assurance.

Threats

The rapid proliferation in 4th generation aircraft capabilities globally has led a to a push for 5th generation capabilities in recent years. But despite a number of nations declaring a desire to join the 5th generation club, only China and Russia appear to have made any significant progress. Despite even these advances, true 5th generation capabilities take considerable time to develop and are difficult to achieve.

Whilst it is important to be aware of higher-end competitors, in the context of the wider operating environment, the introduction of complex integrated air defence systems (IADS) with advanced multi-band radars and highly accurate long-range surface to air missiles (SAMs) also need to be taken into account. These systems have increasingly effective search, acquisition, fire control and engagement radars, they operate in numerous bands and low frequencies to reduce the advantages of stealth, and they are widely dispersed and networked.

Stealth by itself will not always be sufficient to counter high-end IADS threats, so it will need to be complemented by building on information superiority and electronic warfare to ensure future air campaigns can be conducted. The emphasis by competitors on stealth capability development drives home the point that stealth will remain an important component of air warfare. The stealth features that have been designed into the F-35 will enable it to respond to the threat of proliferating IADS and enable it to get closer so it can use sensor fusion to track and kill threats.

The F-35 capability goes way beyond the capability of the platform. Everything from the training, to how the ecosystem is integrated, to how they make the airplane functional "outside of traditional metrics" is what will give us a significant advantage.

Key Conclusions

Studies conducted by The Sir Richard Williams Foundation have concluded that the F-35 is the only viable candidate that will meet the full range of Australia's air combat needs into the future.

The two important goals of the Australian F-35 Program are to deliver a new air combat capability that will meet Australia's needs to 2025 and beyond and deliver a strong Defence industry that supports the F-35.

The 5th generation F-35 is a whole new way of doing business for the ADF and will require a number of key enabler capabilities in order to maximise its potential to make not just the RAAF but key elements of the whole ADF better.

If the ADF wants to limit the F-35 to a tactical role, then that will be very easy to do. But if the ADF wants to expand this ecosystem and include in it other mission sets – including ones that nobody has yet thought of - the capacity is there to do it.

The F-35 is not simply a replacement for the F/A18 but an introduction to a different way of thinking about operations, land, sea and air. It is the epitome of RAAF's Plan Jericho approach; how do we do it better?

Appendix 1

Generational Development of Air Combat Capability

1st Generation: The jet fighters of the immediate post-WW2 and Korean War period.

Despite introducing advances such as the turbojet engine and swept wings, these aircraft essentially retained the same or similar cannon or machine gun armament and gun sights of their piston-engine forebears. Examples of first generation fighters included the NA F-86 Sabre, and the Soviet MiG-15 and MiG-17.

2nd Generation: As the cold war gained momentum in the 1950s, aircraft evolved with the introduction of sustained transonic or supersonic dash capabilities, rudimentary fire control radars and infrared guided air-to-air missiles. Examples include the MiG-19, Hawker Hunter, North American F-100 and Dassault Mystere II.

3rd Generation: As technology rapidly improved and defence budgets increased exponentially, the late 1950s and 1960s saw the introduction of aircraft capable of sustained supersonic flight, carried improved fire control radars and semi-active air-to-air missiles, the first generation of tactical electronic warfare systems and the introduction of multi-role capabilities. Aircraft such as the McDonnell F-4, Vought F-8, Dassault Mirage III, the MiG-21 and MiG-23 are all examples of third generation fighters.

4th Generation: The lessons learned from the Vietnam conflict generally informed the introduction of aircraft with more efficient and powerful turbofan jet engines, 'look-down' Doppler fire-control radars, fly-by-wire flight control systems providing high agility, integral and podded Electro-Optical/Infrared targeting sensors, laser and GPS guided precision weapons, active air-to-air missiles, heads-up displays, and improved electronic warfare systems. This generation is the longest lived of the five generations so far, and includes all the US 'teen-series' fighters, the Mirage 2000, Saab Gripen, the MiG-29 and Sukhoi Su-27/30, China's Chengdu J-10A, and the Dassault Rafale and Eurofighter Typhoon.

5th Generation: The general criteria for being categorised as a 5th generation aircraft includes those systems advanced by later 4th generation aircraft, but adding the all-important designed-in low observable shaping and materials, internal weapons bays, and high degrees of situational awareness through integrated sensors and networking. So far, the only operational 5th generation aircraft has been the F-22A Raptor although the F-35 also meets these criteria. Based on initial reports, the Sukhoi T-50 PAK-FA and Chengdu J-20 are expected to follow suit.

There are also some notable aircraft currently in production or development that have evolved to the point where some of their capabilities span the gap between the 4th and 5th generation categories. Aircraft such as the Block II Super Hornet, Boeing's Advanced Super Hornet and Advanced Eagle concepts, the Sukhoi Su-35 development of the Flanker, the Chengdu J-10B and planned developments of the Typhoon, Rafale and Gripen all offer various features including advanced Active Electronically Scanned Array radars and optical sensors with higher levels of integration, some built-in or added-on low observable features, conformal auxiliary tanks or shaped weapons pods, and advanced electronic warfare systems. These aircraft are generally referred to as 4.5 generation or 4+ generation fighters.

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.