

Operational Test and Evaluation Planning for the Introduction of the F-35 Joint Strike Fighter into Australian Service

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ABSTRACT

Australia is highly likely to become an operator of the F-35A Joint Strike Fighter (JSF) around 2012-2015. The anticipated requirement for the aircraft is to replace the existing capabilities of both the AF/A-18A/B and the F/RF-111C in the fighter/strike/recce roles currently fulfilled by those aircraft. With defence budgets under increasing pressure, it is imperative that the RAAF pursue the optimal airframe to achieve the intended requirement, as well as increase the capability of the RAAF into the future. Although a decade separates us from the introduction of that capability, it is important that operational test and evaluation (OT&E) issues be identified as early as possible so that entry into Australian service and potential capability are maximised. The JSF program will introduce several new technologies into the RAAF that will require the support of OT&E techniques to ensure that transition is smooth and capability is maximised as early as possible.

Keywords: operational, test and evaluation, aircraft, F-35A, joint strike fighter.

INTRODUCTION

The purpose of this paper is to determine how operational test and evaluation (OT&E) principles can be utilised in preparing for the introduction of F-35A Joint Strike Fighter (JSF) to the Royal Australian Air Force (RAAF) inventory. If used correctly, OT&E should assist the Australian Defence Force (ADF) in determining whether the JSF platform fits into the RAAF and ADF airpower systems.

Historically the RAAF has purchased either existing aircraft to fulfil a niche within the ADF structure, or untested aircraft in an attempt to gain a technological lead in defence.

By choosing to bypass existing technologies such as the Eurofighter Typhoon, the SAAB Gripen, the Dassault Rafale, and the Boeing Super Hornet identified by Project Air 6000, the

¹ This paper forms part of the research work conducted as a post-graduate student of the University of South Australia.

Government has chosen to risk the ability of an aircraft yet to reach production to fulfil the Australia's future air combat capability, a risk which 'will still require an act of faith' (Ferguson, 2003, p. 28). However, given the tools currently available to OT&E, it is likely that the ability of the F-35 JSF to meet the RAAF's needs will be able to be assessed from an early stage.

Background. When Australia recently joined the JSF system development and demonstration (SDD) phase, the RAAF gained access to test data not normally available during acquisition. Access to the data will allow the RAAF to identify potential operational issues and risks caused by the new capability. The information will be equally as useful in the selection and introduction of other future defence acquisitions such as uninhabited combat air vehicles (UCAVs) and future air-to-air refuelling aircraft that are seen as force multipliers.



Figure 1: Joint Strike Fighter (Net Resources International Limited, 2003)

For example, Lockheed Martin will be responsible for the introduction of the autonomous logistic system (ALS) that aims to significantly reduce operating cost of the aircraft. The RAAF is likely to adopt the ALS, but will need to radically review how the current Australian maintenance and logistic support is provided.

The RAAF has selected the F-35A JSF to fulfil the F-111 strike and F/A-18 fighter/attack roles when these current aircraft reach their life-of-type around 2012-15. In making this early selection, the RAAF has an opportunity to gain an early insight into the capabilities of the F-35 aircraft as its development matures.

Although seen as a one-for-two exchange, in actual fact the aircraft will be supported in its role(s) by complementary capabilities currently being acquired, such as Project Air 6000 Phase 1c Uninhabited Combat Air Vehicle (UCAV) and Project Air 5402 Phase 1 future air-to-air refuelling capability. Both of these are planned to come into service prior to the F-35 JSF (Ferguson, 2003, p. 26). By getting in early the RAAF will be able to shape the introduction of these capabilities to ensure that all needs are covered.

PLANNING FOR OT&E

The RAAF has the opportunity to plan well ahead for the OT&E of the F-35 JSF. By definition, OT&E² requires testing of the system under realistic conditions by representative users. However, much of the OT&E program can be conducted prior to the introduction of the aircraft into RAAF service.

Originator Testing. The lead customers in the JSF program are the US Department of Defense (procurement for the US Air Force, the US Navy, and the US Marine Corps) and the UK Ministry of Defence (procurement for the Royal Air Force and the Royal Navy). Both lead customers will conduct operational testing which may be available for RAAF participation, witnessing or review. The methods and results of this originator testing will assist in the development of the RAAF's OT&E strategies and techniques. Lead customer OT&E has been broken into several phases that will align with various phases of the acquisition process. Table 1 shows the relationship between the USAF development and acquisition and the OT&E programs.

Activity	Acquisition Phase	Time Frame	Supporting
OT-I	System Development and Demonstration (SDD)	FY 03	Preliminary Design Review
OT-IIA	SDD	FY 04	Critical Design Review
OT-IIB	SDD	FY 05	Defence Acquisition Executive (DAE) Internal Program Review (IPR) 1
OT-IIC	SDD	FY 06	DAE IPR 2
OT-IIID	SDD	FY 08	DAE IPR 3
OT-IIIE	SDD	FY 09	DAE IPR 4
OT-IIIF	SDD	FY 11	DAE IPR 5
OT-IIIG	SDD	FY 12	Defence Acquisition Board Review
OT-III (FOT&E)	Post - SDD	To be determined (TBD)	TBD
OT-IV	Post - SDD	TBD	TBD

Table 1: USAF's F-35 JSF Acquisition Decisions Supported by OT&E
(after Air Force Operational Test and Evaluation Center, 2003b)

The USAF Operational Test and Evaluation Center (AFOTEC) conducted an early operational assessment (EOA) on behalf of JSF Program Office to identify program risks. This EOA was completed prior to the preliminary design review (PDR), and considered operational risks resulting from the program's progress, design expectations and review of the JSF documentation. Limitations to an EOA are the inability to resolve effectiveness and suitability issues without access to typical operational scenarios, however the use of modelling and simulation assists in assessing whether the assumptions are valid, and aids in identifying risk (Air Force Operational Test and Evaluation Center, 2003a, p. iii).

² OT&E is T&E conducted under realistic combat conditions with representative users of the system, in the expected operation context, for the purpose of determining its operational effectiveness and suitability to carry out the role and fulfill the requirement that it was intended to satisfy (Harris, 2002).

An operational assessment will assess potential operational effectiveness and suitability issues prior to the critical design review. The focus of these assessments is on programmatic voids, areas of risk, testability of requirements, significant trends noted in development efforts and the ultimate ability of the program to support an adequate period of evaluation during dedicated operational test. Operational assessments will not however, substitute for the independent period of dedicated operational testing necessary to support decisions on system release for operational employment (AFOTEC, 2003, p. 31).

It is more likely that issues and risks identified during EOA and other operational assessments will remain unresolved, at least until (full) operational T&E such as operational evaluation is conducted and reported upon.

Follow-on operational test and evaluation should be conducted to validate the operational effectiveness and suitability of in-service F-35 JSF aircraft and systems retro-fitted with modifications, ancillary systems or subjected to major upgrades.

Identifying the User's Need. While the USA and the UK have identified their own user's need, these do not necessarily reflect the need of the RAAF. The RAAF user's need is to replace the capabilities of both the F/RF-111C and F/A-18 aircraft, as both types will be at the end of their useful life by about 2015.

Another aspect of the RAAF user's need is to retain a technological advantage in Australia's region for the future (for some 30 years). The Super Hornet, the Gripen, the Rafale and the Typhoon were not seen to provide, or able to maintain, that technological advantage over the expected operational life (Ferguson, 2003, p. 28). The JSF concept however does promise a step ahead of these aircraft in terms of capability.

From the respective governments' viewpoints, the need is also for the next generation aircraft to be affordable. The costs for tactical aircraft development, production (per airframe) and operation have been spiralling for several generations of aircraft now, to the point that this increasing cycle is likely to end with the F-22 Raptor since no country (apart from the USA) can afford to equip its air force with these aircraft (Fighter of the Future, 2003, p. 8). JSF is envisaged as breaking this increasing cycle of tactical aircraft costs, as JSF not only intends to be a cheaper aircraft to buy but also aims to substantially reduce the operating cost of the system utilising an autonomous logistics system (ALS).



Figure 2: F-22 Raptor
(United States Air Force, undated)

SYSTEMS APPROACH TO OT&E

Past aircraft acquisitions have been based on the need to fulfil a particular niche, or have been the result of political decisions. Aircraft such as the Mirage III and the Macchi MB326, while good aircraft in their time, were not necessarily best suited to Australian conditions. A similar example was the modification of the RAAF's B707 aircraft to drogue-refuelling only, which is compatible with the F/A-18 Hornet (which had a critical need for extension of its combat radius), yet is incompatible³ with the strike capability asset (the F-111) which only accepts boom-refuelling.

The introduction of the JSF into RAAF service will need to be assessed in light of a total air power system involving other platforms in an integrated environment. The operational concept document, as the source document for defining the user's need, will need to clearly address the requirement for fighter, strike and recce operations, which can be assessed by OT&E, rather than simply describing the airframe requirements based around the F-35 JSF specifications and the number of airframes that the RAAF can afford.

OT&E will need to assess how compatible the F-35 is with other RAAF systems such as the airlift capability based on the C-130J, the lead-in fighter capability based upon the Hawk, future air-to-air refuelling aircraft, ADF logistics, and RAAF technical training to name a few.

OT&E should also assess the ability of the aircraft to survive a mission in the expected threat environment. This includes how the stealth technology of JSF performs in the Australian operational and climatic environments.

The Australian Defence Force is operating more often in coalition forces, so OT&E will need to be planned to address interoperability issues with the forces of likely coalition partners. For instance, with the F-35 JSF in RAAF service, the RAAF will have common airframes with the USAF and the RAF, and there may be a need to assess a situation where Australian aircraft are operated within a coalition squadron/wing utilising USAF or RAF maintenance support units. If the RAAF adopts the JSF's ALS, the issue may not be overly complex if Lockheed is the ALS manager for both the RAAF and foreign F-35 JSF services.

OT&E Structure. While the user's need may be well defined in say the operational concept document, the methodology for the approach to OT&E testing will need to be clearly outlined through the use of a test concept document. The test concept document should define the responsibilities of the project office and other likely key test agencies, and map the T&E of the system from concept approval to retirement. The test concept document, and later the T&E master plan (TEMP) which provides greater detail about the overall T&E program, must identify the critical operational issues (COIs) to be addressed through OT&E. The USAF TEMP for the F-35 JSF identifies two forms of COIs – (1) effectiveness COIs as those missions that the F-35 weapon system must perform, and (2) suitability COIs as 'missionised (sic) tasks users must perform to support the F-35 weapon system' (Air Force Operational Test and Evaluation Center, 2003a, p. 32).

Examples of COIs to be addressed during RAAF OT&E are:

Effectiveness Issues:

- Will the F-35 fulfil the recce role?
- Will the F-35 fulfil the close air support⁴ role?
- Will the F-35 fulfil the combat air patrol⁵ role?

³ However, the future air-to-air refuelling system being procured under Project Air 5402 Phase 1 will be both drogue (received by Hornet and Hawk) and boom capable (received by F-111 and AEWAC).

⁴ Defined as 'air action against targets in close proximity to friendly ground forces that require detailed integration of each air mission with fire and movement of those forces' (Royal Australian Air Force Aerospace Centre 2002).

- Will the F-35 be able to survive in the hostile Asia/Pacific EW environment?

Suitability Issues:

- Will the F-35 generate the required sorties?⁶
- Will the F-35 be capable of in-flight refuelling from the new tanker aircraft?

IDENTIFYING RISK

Given the manner in which the RAAF has selected the F-35 JSF, there are a number of risks that can be identified early. Of these, technical risks must be addressed during OT&E to determine whether they have been satisfactorily resolved.

Risk may be broadly defined⁷ as the likelihood of an occurrence versus the consequence of that event. The trade-off for acceptance of risk is often the cost of resolution. For instance, it is planned to be power the F-35 initially with the existing F-22 engine (Ferguson, 2003, p. 32) while three alternate engine manufacturers are funded to develop separate, but compatible, engines. However with several strategies such as this (particularly in the avionics and communications areas), there remains a risk that the F-35 program will parallel that of the F-111 (and arguably the AP-3C), in that the inclusion of too much new technology at once will prove difficult to introduce into service. Although Lockheed has identified these risks and taken steps to reduce them, the F-35 may prove not to be as capable early in its operational life as hoped.

Other risks have been identified by the USAF's early operational assessment that the RAAF would do well to analyse and address early in the context of the Australian environment. There are also risks yet to be fully identified, such as those specific to the Australian operation of the F-35 capability, including the issues arising from Australian-unique modifications to the aircraft and the introduction of this capability within the Australian logistics environment.

US Risk-Reduction Strategies. The F-35 JSF program has attempted to get an early start on the testing of new technologies for the aircraft in as close to operational environment as permissible without having a production F-35A. This includes airborne testing of the new multi-sensor avionics suite by mounting it on an existing airframe (the BAC-111), and flight testing of the 'power-by-wire' (i.e. all electric) flight control system fitted to an Advanced Fighter Technology Integration (AFTI)/F-16.

Some testing for the F-35 JSF conducted closer to home includes the AFOTEC/ARDU Small Smart Bomb project, which sought to validate computational fluid dynamics used in the F-22, JSF and UCAV stores separation analysis, using existing wind tunnel technology and flight testing with an RAAF F-111G (Grove et al, 2003.) Testing in this manner will allow some data gathering and validation of the hypotheses used in modelling and simulation.

RESOLUTION OF THE USER'S NEED

Where developmental T&E (DT&E) will verify the F-35 JSF aircraft against a series of technical criteria, OT&E will test the capability of the solution, that is the F-35 JSF, to meet the user's needs. The presumption for the RAAF has been that the F-35 JSF will replace both the F/RF-111C and the F/A-18A in all of the current roles. One of the COIs presented above asked whether the F-35 JSF will fulfil the recce role. However it does not necessarily follow

⁵ Defined as 'patrols mounted over an objective area, ... or over an air defence area, for the purpose of intercepting and destroying hostile aircraft before they reach their targets' (Royal Air Force, 1993, pp. 49-50).

⁶ This will validate the number of airframes purchased to achieve the sortie rate, as well as validating the logistic support and maintenance requirements.

⁷ Risk is defined as the chance of something happening that will have an impact upon objectives. It is measured in terms of consequences and likelihood (Standards Association of Australia, 1999).

that F-35 JSF will be best suited for that role. It may well be that aUCAV system would be the preferred option. An early operational assessment of both the F-35 JSF and potentialUCAVs would provide some indication of resolution of this issue.

To determine whether the F-35 JSF satisfies the user's need (in say the recce role) a standard for measuring the success is needed by which the capability can be assessed. Within the OT&E process, such standards are pre-determined as measures of effectiveness (MOEs). Without digressing into a full discussion of MOEs, it is worthy to note that the stealth MOE analogy for the F-117 provided by Sproles (2000, p. 5) is equally as valid for F-35 JSF. Another MOE for the F-35 JSF could be 'the probability of destroying an armoured target (e.g. a main battle tank) with a single store.' If the probability is high, then the F-35 JSF airframe, and its complementary smart weapons and advanced avionics are probably working well and the user (ground commanders concerned with decisive anti-armour support) satisfied.

REPORTING

At the completion of testing and following analysis of the results, it is important that the report generated remains objective. Without the ability to provide positive and negative criticism of the system, the user will not be able to judge whether the system meets the original need. Therefore the OT&E agency is required to remain objective at all times. The RAAF has the lead-time with the F-35 JSF program to consider which agency can best maintain the objectivity needed to lead the OT&E program.

RAAF INITIATIVES

A number of steps related to OT&E for the F-35 JSF have already been introduced by the RAAF to prepare for introduction of the aircraft. These include:

- Establishment of the JSF Project Office, to provide guidance on the OT&E program and to provide authority to conduct testing.
- Joining the JSF program as a partner, allowing an early insight into the aircraft development and gain access to information such as the USAF JSF TEMP and EOA reports.
- Establishment of the RAAF F-35 JSF TEMP, defining the likely requirements of OT&E as the capability is developed.
- Development of the T&E Capability Support Plan, to provide the RAAF with a structure for OT&E management not yet available in the RAAF.
- Establishment of Force Element Group (FEG) T&E cells, to provide the RAAF with a capability for the conduct of OT&E not previously available in the RAAF.

CONCLUSION

With Australia joining the F-35 JSF system development and demonstration program, the RAAF has an opportunity to plan well ahead for its own OT&E program. By participating in, witnessing, or at least reviewing the results of, the lead customers' testing, the RAAF will learn the lessons of the USAF and the RAF to be applied to the indigenous OT&E program. However, the RAAF must realise that its user's needs for the JSF system will not mirror exactly the user's needs of the USAF and the RAF.

The RAAF's OT&E will need to be based upon a set of clearly pronounced critical operational issues (COIs), to be resolved by pre-determined measures of effectiveness (MOEs). The COIs for the RAAF may include unique issues, such as compatibility with existing RAAF and ADF systems, and Australia's likely role in future coalition operations.

The other issue to be resolved in the OT&E planning cycle is which agency should be the lead for the RAAF OT&E program. The lead agency requires to be sufficiently independent

for it to be objective in its assessment of the operational effectiveness and the operational suitability of the F-35 JSF to meet the ADF's needs.

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