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Performance Audit

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Acquisition of Aerospace Simulators

Department of Defence

The Auditor-General Audit Report No.17

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Photo source: Photographs provided to the ANAO courtesy of F-111C Simulator project and Air Lift Simulator project management, Department of Defence.

Canberra ACT
25 November 1998

Dear Madam President
Dear Mr Speaker

The Australian National Audit Office has undertaken a performance audit of the Department of Defence in accordance with the authority contained in the *Auditor-General Act 1997.* I present this report of this audit, and the accompanying brochure, to the Parliament. The report is titled *Acquisition of Aerospace Simulators.*

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

Yours sincerely

P. J. Barrett
Auditor-General

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

AUDITING FOR AUSTRALIA

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Abbreviations/Glossary

AAD	Aerospace Acquisition Division
ADF	Australian Defence Force
AGPS	Australian Government Publishing Service
ALSIM	Air Lift Simulators Project
ANAO	Australian National Audit Office
AUP	Avionics Update Program
B707	Boeing 707 aircraft
C-130J-30	Lockheed Martin Corporation 'Hercules' Transport Aircraft - Stretched Fuselage Variant
DAC	Design Authorised Contractor
DAO	Defence Acquisition Organisation
DER	Defence Efficiency Review
DESTEC	Defence Science and Technology Committee
DSTO	Defence Science and Technology Organisation
EDL	Economic Design Life
F/A-18	McDonnell Douglas F/A-18 aircraft
F-111C	Lockheed Martin F-111 aircraft - 'C' Model
F-111F	Lockheed Martin F-111 aircraft - 'F' Model
F-111G	Lockheed Martin F-111 aircraft - 'G' Model
GAO	General Accounting Office (of the USA)
HLA	High Level Architecture
JCPA	Joint Committee of Public Accounts
LOT	Life of type
M&S	Modelling and simulation
NAO	National Audit Office (of the UK)
NATO	North Atlantic Treaty Organization
RAAF	Royal Australian Air Force
RMA	Revolution in Military Affairs
RMP	Risk Management Plan
SIMPE	Simulator Project Environment
SRG	Strike Reconnaissance Group
TNA	Training Needs Analysis
USAF	United States Air Force

Summary and Recommendations

Audit Summary

Background

1. Simulators are devices that provide personnel with training and practice by reproducing the behaviour of operational equipment. Defence records indicate that since 1960 the Defence Organisation has spent about $1 billion on acquiring simulators for training purposes. Over the next five years Defence proposes to spend a further $1.1 billion on simulation.

2. Some military training can be carried out safely only by means of simulation. In addition, simulation is being used in an increasing number of military environments. This has been made possible through the creative combination of new technologies and new equipment, specifically enabled by smaller, faster and more powerful computers.

3. Although simulation is not a replacement for all conventional training it plays a crucial role in training the Australian Defence Force (ADF) today. Frequently, simulation enables specific training objectives to be met with fewer people, in smarter ways, with greater economy, efficiency and effectiveness, and without damaging the environment. Simulators can improve training and help extend the life of type (LOT) of major capital equipment which cost many billions of dollars.

4. The audit examined Defence's acquisition of aerospace simulators, which are used to train personnel to operate aircraft. The training and economic benefits of aerospace simulators have long been recognised by commercial airline operators which use them extensively.

5. This report examines examples of an important and growing area of Defence acquisition: an area where the 'right' acquisition decisions can save lives, reduce injuries, improve training, preserve weapons systems, avoid munitions depletion, preserve the environment and save many millions of dollars.

6. Aerospace simulators acquired in the light of a training needs analysis (TNA) and an appropriate cost:benefit study can yield significant benefits. These include:

- increased efficiency as training is not subject to weather conditions or aircraft availability;
- increased flying safety;
- extended life of type (LOT) of expensive, long lead-time equipment;

- lower training costs; and
- reduction in operational and environmental disturbance.

Audit objective and scope

7. The objective of the audit was to assess whether Defence had developed appropriate policies to provide guidance to personnel in the acquisition and use of aerospace simulators and the effectiveness of its procedures in achieving best value for the Commonwealth in relation to aerospace simulators.

8. The scope of the audit was restricted to aerospace simulators because of their importance for Defence training and because acquisition issues that apply to them apply to many other training simulators in Defence. Aerospace simulators have a particular significance for safety of personnel.

Technical developments

9. Recent advances in technology — including computer hardware and software and information technologies— have enabled the development of a new generation of simulators that are far more realistic and useful as training devices than their immediate predecessors. Simulation is increasingly seen as an effective and economical substitute for some 'live' training in the Defence environment.

Case studies

10. For the purposes of the audit, the ANAO selected four aerospace simulator acquisition projects as case studies. These were the simulators for the ADF's B707, F-111C, Black Hawk and the yet-to-be acquired C-130J-30 aircraft.

Key findings

Simulation policy and standards

11. The ADF does not have a comprehensive policy on aerospace simulators or other forms of simulation. This appears to be inhibiting the ADF's ability to exploit the opportunities now offered by simulation technology. A Defence simulation policy should clearly define a development strategy as well as guidelines and standards for simulation and provide a mechanism for coordination of aerospace and other simulation activities. The draft Defence Simulation Policy and draft Simulation Master Plan mentioned in the Defence Efficiency Review Report (March 1997) are not yet complete.

Training needs analysis

12. Simulators are increasingly being used for training in a wide variety of applications across the Defence Organisation. Some of the simulator acquisition projects would have had better outcomes had there been a training needs analysis (TNA) prior to acquiring the simulator. A TNA is fundamental to the acquisition process.

Consideration of simulators when buying capital equipment

13. Aerospace simulators range from complex expensive full-flight and mission simulators to relatively simple and inexpensive 'part-task trainers'. The advantages of using simulators for some training purposes are so significant that, whenever a major Defence equipment acquisition is being proposed, consideration should also be given to acquiring simulators for use as part of the routine training regime.

Simulator specifications

14. Components of the F-111C simulator were built to costly military specifications. The ANAO considers that any proposal to build simulator equipment to costly military specifications should be pursued only after considering a sound business case for doing so.

Data acquisition

15. Flight simulators need to have data on the operational performance and behavioural characteristics of the equipment to be simulated. Data acquisition strategies are a crucial aspect of simulator acquisitions and vital to their effectiveness. The strategies used in the different projects examined varied considerably. Defence needs to retain principal responsibility for acquiring the data.

Contracts and data

16. When negotiating for the acquisition of major equipment Defence should seek access to relevant data on the operational performance and behavioural characteristics of the equipment for simulation purposes as part of the contracted arrangements.

Risk management plan

17. The ANAO found that two of the four projects examined did not have risk management plans and did not manage risk satisfactorily.

Skill sets and contact with contractors

18. The projects examined demonstrated the advantages of regular face-to-face communications between appropriately qualified and experienced project staff and the contractors involved. They also reinforced the need to have the 'right' experience in project management and to retain skills appropriate to the project. This assisted the B707 and C-130J-30 simulator acquisitions.

Staff turnover

19. Two of the four projects examined suffered from high staff turnover that led to low retention of project knowledge and unnecessary extra costs, the constant need to train new staff, and consequent delays in the projects. (Defence proposals mentioned at paragraph 3.28 of the report should help alleviate these problems.)

Configuration management

20. The relevance and training usefulness of some simulators declined because they were not kept up to date with the aircraft. If functional changes are made to an aircraft or its equipment that affect its operational characteristics, comparable changes may be required to any simulation equipment to preserve the integrity of the relationship between it and the intended training purpose.

Outcomes

21. The outcomes of the four simulator acquisitions varied. The B707 and C-130J-30 simulator projects are expected to lead to the delivery of useful training devices within budget and on time. The F-111C simulator acquisition should result in a significantly enhanced mission training capability for the Strike Reconnaissance Group aircrews. The Black Hawk simulator acquisition project should also result in a high-fidelity training device that will enhance Black Hawk aircrew training and release three Black Hawk helicopters from training activities. The latter project is, however, running some 13 months late. Problems encountered on the projects have tended to be associated with high turnover of staff.

22. The report raises various matters of concern that arose in the course of the audit and sets out seven recommendations to address them. They concern the need for Defence to:

- issue a simulation policy and master plan to guide the acquisition of simulators;
- conduct appropriate training needs analyses when acquiring major equipment;
- acquire simulators built to military specifications only if a business case supports the cost of doing so;
- retain responsibility for acquiring equipment performance data for simulators;
- seek access to equipment performance data for simulators;
- acquire simulators according to a risk management plan; and
- update simulators to ensure they represent the current functional status of the equipment they simulate.

Defence response

23. Defence responded positively to the audit and agreed to implement the ANAO recommendations, two subject to qualification.

Recommendations

Set out below are the ANAO's recommendations with report paragraph references and an indication of the Defence response. The ANAO considers that Defence should give priority to Recommendation Nos 1 and 2.

Recommendation No.1 Para. 3.6

The ANAO recommends that Defence promulgate a simulation policy and master plan with standards and guidelines for the acquisition of simulators, and review and up-date these documents to keep pace with developments in the simulation technologies that are available.

Defence response: Agreed.

Recommendation No.2 Para. 3.10

The ANAO recommends that Defence, when acquiring major items of capital equipment:

(a) undertake appropriate analysis to identify cost-effective and efficient training devices (including simulators); and

(b) acquire simulation equipment only after an appropriate training needs analysis that identifies the most appropriate suite of training equipment.

Defence response: Agreed.

Recommendation No.3 Para. 3.13

The ANAO recommends that the specifications for Defence aerospace simulators should stipulate military specifications for particular components and / or aircraft design regulation requirements only when a business case has established a need for such specifications.

Defence response: Agreed.

Recommendation No.4 Para. 3.17

The ANAO recommends that Defence retain the principal responsibility for ensuring the acquisition of appropriate data for simulation purposes, while recognising that the actual work may be carried out by the prime contractor, under instruction from Defence.

Defence response: Agreed, with qualification.

(See paragraph 3.18.)

Recommendation No.5 Para. 3.20

The ANAO recommends that, when negotiating for the acquisition of major capital equipment, Defence should seek access to appropriate equipment performance data for simulation purposes.

Defence response: Agreed.

Recommendation No.6 Para. 3.24

The ANAO recommends that Defence proceed with the acquisition of any major aerospace simulator according to an associated risk management plan prepared at the outset of the acquisition process.

Defence response: Agreed.

Recommendation No.7 Para. 3.37

The ANAO recommends that, to help keep aerospace simulators at their full training capability, Defence:

(a) ensure that, when aircraft are modified or upgraded in a way that changes their functional characteristics, corresponding changes are made to the functional characteristics of any simulators for the aircraft; and

(b) establish simulator configuration management procedures for recurrent fidelity checks to confirm that simulators are maintaining their proper functional characteristics.

Defence response: Agreed, with qualification.

(See paragraph 3.38.)

Audit Findings and Conclusions

1. Introduction

Members of the Armed Forces must train effectively to achieve and maintain individual and collective operational capability. Simulators, in combination with more traditional forms of training, have a key role in the achievement of this objective.[1]

1.1 Simulators are devices that provide personnel with training and practice by reproducing the behaviour of operational equipment. Appendix 1 provides background information on simulators. The Department of Defence defines a simulator as:

> *a device which employs simulation to replace a real world system or apparatus, eg, for training purposes.*[2]

1.2 Aerospace simulators of the types examined in this audit are training devices that simulate the cockpit and cabin of an aircraft in various operating situations (taking off, flying, landing, etc) without themselves becoming airborne. Aerospace simulators acquired in the light of a training needs analysis (TNA) and an appropriate cost:benefit study can yield the following benefits:

- increased efficiency as training is not subject to weather conditions or aircraft availability;
- increased safety while training;
- lower training costs;
- release of aircraft from training to operational use;
- the facility to practise situations which, for reasons of expense, safety or practicability, cannot be rehearsed in the actual aircraft; and
- reduction in operational and environmental disturbance.

1.3 The Australian Defence Force (ADF) uses aerospace simulators for many different training tasks, ranging from basic training to complex mission rehearsal. In addition, many 'part-task trainers' (generally smaller and less complex simulators) are used to train personnel in tasks such as cockpit procedures.

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1 Opening paragraph of Report of the National Audit Office, *Ministry of Defence: Use of Simulators in Training,* London, HMSO, 6 November 1992, p.1. This applies equally to the Australian Defence Force today.

2 Department of Defence, *Draft Defence Simulation Master Plan,* Edition 1, February 1998, p.A-9.

1.4 The cost of aerospace simulators varies considerably. During the course of the audit the ANAO saw effective simulators being used by the ADF that ranged in cost from less than $100 to tens of millions of dollars. Although acquisition of simulators needs to be considered concurrently with the acquisition of the aircraft, they are often separate acquisition projects because simulators are normally manufactured by specialist firms, not by aircraft manufacturers.

1.5 Defence records indicate that since 1960 the Defence Organisation has spent about $1 billion on acquiring simulators for ADF training purposes. Over the next five years Defence proposes to spend a further $1.1 billion on simulation.[3] The Defence Efficiency Review report (March 1997) commented that:

> *The Defence Simulation Coordination Group has produced a draft Defence Simulation Policy and draft Simulation Master Plan which aim to address the need for an expanded support role for modelling and simulation while providing a coordinating mechanism for the development of these tools across Defence.*[4]

The ADF's Policy and Master Plan have not yet been completed.

Audit objective and scope

1.6 The objective of the audit was to assess whether Defence had developed appropriate policies to provide guidance to personnel in the acquisition and use of simulators and the effectiveness of its procedures in achieving best value for the Commonwealth in relation to aerospace simulators.

1.7 The scope of the audit was restricted to aerospace simulators because of their importance for Defence training and because acquisition issues that apply to them apply to many other training simulators in Defence. Aerospace simulators have a particular significance for safety of personnel. The audit considered the justification for obtaining selected simulators and the management of the acquisition projects from the point of contract signature onwards. It did not consider the technical aspects of tender specifications and tender selection. Nor did it examine contractors' performance.

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[3] Department of Defence, Defence Industry and Procurement Infrastructure Division.

[4] *Future Directions for the Management of Australia's Defence: Addendum to the Report of the Defence Efficiency Review: Secretariat Papers,* 1997, Department of Defence, Canberra, p.330.

Audit criteria

1.8 The following criteria were formulated and applied during the audit to help assess whether the particular aerospace simulator acquisitions selected for study in this audit would achieve best value for the Commonwealth:

- the decision to acquire the simulator was made after consideration of a comprehensive training needs analysis (TNA);
- the total cost of the simulator acquisition and its maintenance had been assessed prior to purchase;
- a cost:benefit analysis identifying alternative solutions to the training needs had been undertaken;
- the acquisition process involved an appropriate and effective data acquisition strategy;
- the acquisition process provided confidence that the simulator and its related equipment performance data were acquired in an economical manner; and
- management of the acquisition proceeded according to a systematic risk management plan.

Audit methodology

1.9 The methodology used in this audit included:

- background research on simulators in general and aerospace simulators in particular;
- review of Defence policies and procedures with regard to the specification and acquisition of aerospace simulators; and
- review of four aerospace simulator acquisitions against the audit criteria.

1.10 The specific techniques used included literature searches; review of international information on simulators; interviews with relevant Defence personnel; discussions with the operators of simulators in the private sector; a review of Defence files related to the acquisition of each simulator; and the engagement of specialist consultants to review and critique aspects of the audit work.

Audit resources and cost

1.11 Consultants from I.M.Thomas Pty Ltd and PALM Management Pty Ltd provided advice to the ANAO during the preliminary study for the audit. Field work for the audit was conducted between December 1997 and July 1998. The ANAO put the proposed report of the audit to Defence in September 1998 for comment. Relevant extracts were also provided to the simulator contractors. The report was completed having regard to comments provided in October. The audit was conducted in conformance with the ANAO Auditing Standards and cost $275 000.

2. Case Studies

2.1 This chapter outlines audit findings from each of the four simulator acquisition projects selected as case studies. These were the aerospace simulators for four kinds of aircraft in the ADF; namely the B707, C-130J-30, F-111C and Black Hawk aircraft. Comments on those case studies are set out below. Background information on the four ADF aircraft types is at Appendix 2.

2.2 The B707, the C-130J-30 and the Black Hawk simulators are commonly referred to as 'full flight' simulators. The Black Hawk simulator is also a mission simulator, as is the F-111C simulator. Full flight simulators are designed to train flight crew to operate the aircraft in most of the circumstances that the aircraft might conceivably become involved. These include take-off and landing procedures, flying maneuvers and emergency situations.

2.3 There are differences between the ways in which commercial and military aerospace simulators are used. In a commercial environment, aircrew are trained specifically to operate with maximum safety. In contrast, military aircrew need to train to operate at the very edge of the 'flight safety envelope' to gain maximum military training benefits.

2.4 Each of the simulators examined in this audit was designed primarily for pilot training and/or mission training of aircrew for one specific type of aircraft in isolation. A trend in other developed countries is to use linked interoperable simulators for joint (combined Services) and cooperative (multi-national) training exercises.

2.5 For simulators to be able to be linked they need a number of features including the ability to use common data standards, and prudent administration would indicate that simulation data guidelines would be beneficial. A formal training needs analysis (TNA) would be needed to identify ways of fully exploiting the opportunities now offered by simulation technology including capabilities to participate in beneficial joint and/or combined training opportunities.

2.6 The B707, C-130J-30 and Black Hawk simulators all adopted a variation of a commercial airline process for accrediting the simulators in the absence of a Defence accreditation standard or policy.

Interior view of cockpit of the B707 simulator.

B707 simulator

2.7 A Boeing 707 full flight simulator is being acquired to replace a simulator made in 1969 which is now of limited training value.

2.8 Air Force has five Boeing 707-338C aircraft. Economic considerations prevent their replacement in the near future. In these circumstances, a case was made for the acquisition of a B707 full flight simulator on the grounds that it would extend the life of type (LOT) of the B707 aircraft. Defence advised that it will do this by replacing use of aircraft with use of the simulator for many training activities including some high-cycle[5] and high-risk aspects of flying.

ALSIM Project

2.9 Defence started the B707 and C-130J-30 simulator acquisition projects as separate projects. They were subsequently combined as the Air Lift Simulator (ALSIM) Project to gain savings from joint management. Both simulators are being manufactured by CAE Electronics in Montreal, Canada, under a single contract. The combined budget for both simulators is $61.8 million.[6]

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5 'High-cycle' refers to raising and lowering the aircraft landing gear and varying the amount of engine thrust (power) more frequently than in 'normal' flying for the particular aircraft type.

6 Because of the number of shared components it is not feasible to quote separate costs for the two simulators.

The decision to buy

2.10 The decision to buy a B707 simulator was based on a cost:benefit analysis of options — including training aircrew overseas — for extending the service life of the aircraft and safety considerations. Although some training needs were identified and taken into account, a formal TNA was not undertaken at the time.

2.11 Training in an aircraft simulator is significantly cheaper than training in the aircraft and certain training routines that are too dangerous to be carried out in aircraft can be performed in a simulator. Air Force estimated that the acquisition of the B707 simulator would lead to savings totalling $59.1 million to the year 2010.

2.12 Acquisition of the simulator would also enable the transfer of high-cycle training hours to the flight simulator, thus prolonging the LOT of the existing B707 aircraft.

2.13 The major capability submission (dated 2 October 1991) recommending the acquisition of the B707 simulator stated:

> *A critical factor in the B707 EDL[7] is the accumulation of cycles. 'Cycles' refer to the cycling of landing gear and variance of engine thrust. Since the RAAF acquired the first B707 from Qantas in 1979 the cycle rate has drastically increased due to RAAF training requirements and the need to rapidly progress relatively inexperienced pilots through to aircraft captaincy. While the aircraft accumulated .17 cycles per hour in airline use the average cycle rate is now 1.6 cycles per hour. This increase is due in part to increased usage of the aircraft for flying training which can consume up to 6 cycles per hour during the circuit element of flying training. ADF operational tasking differs from airline operations and also results in a slight increase in the cycle rate. Clearly, the nature of RAAF flying training is wearing out the aircraft and accelerating the need for a re-equipment programme. While economic factors would preclude the replacement of the aircraft in the short term, options must be considered to overcome the simulator deficiencies and to contain the escalating costs of maintaining an ageing aircraft. [paragraph 9]*

2.14 The ANAO was informed that training for Defence personnel in a commercial B707 full flight simulator in Australia was not a feasible option as a B707 simulator of appropriate fidelity[8] was not available.

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7 Economic Design Life.

8 In the simulator context, *fidelity* means the degree of accuracy with which the item or event being simulated is a good representation of the actual item or event.

Contract management

2.15 The ALSIM Project team in Defence developed a 'partnering' relationship with the CAE Electronics Air Lift Simulator project team based on a common goal: the delivery of two high-fidelity flight simulators to Air Force on time and within budget. The relationship is based on open and effective communication and appears to have helped in achieving outcomes and mitigating risk.

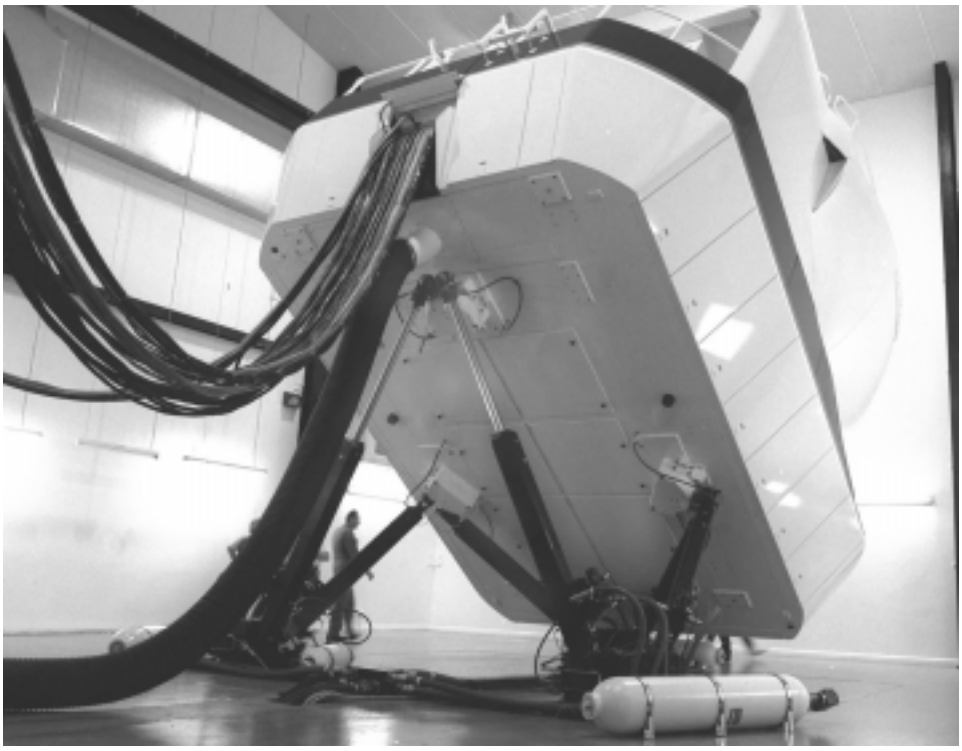
2.16 Throughout contract negotiation and contract management the Defence team has sought to adapt CAE's standard practices to meet Defence needs, rather than try to impose a stringent military approach to products that are to be operated in a 'commercial support' environment. Put another way, simulators do not fly, let alone go to war, and do not necessarily have to be built to rigorous military specifications and/or aircraft design standards designed for equipment that may need to operate under particularly harsh and testing conditions.

2.17 Continuity of key Defence staff members — and their associated skills and knowledge — appears to have been a major factor in the success of this project. The ALSIM Project has had only one Project Manager, but there have been three Project Managers for the Black Hawk simulator project and four Project Managers for the F-111C simulator project. There have been changes of other members of the ALSIM Project Team.

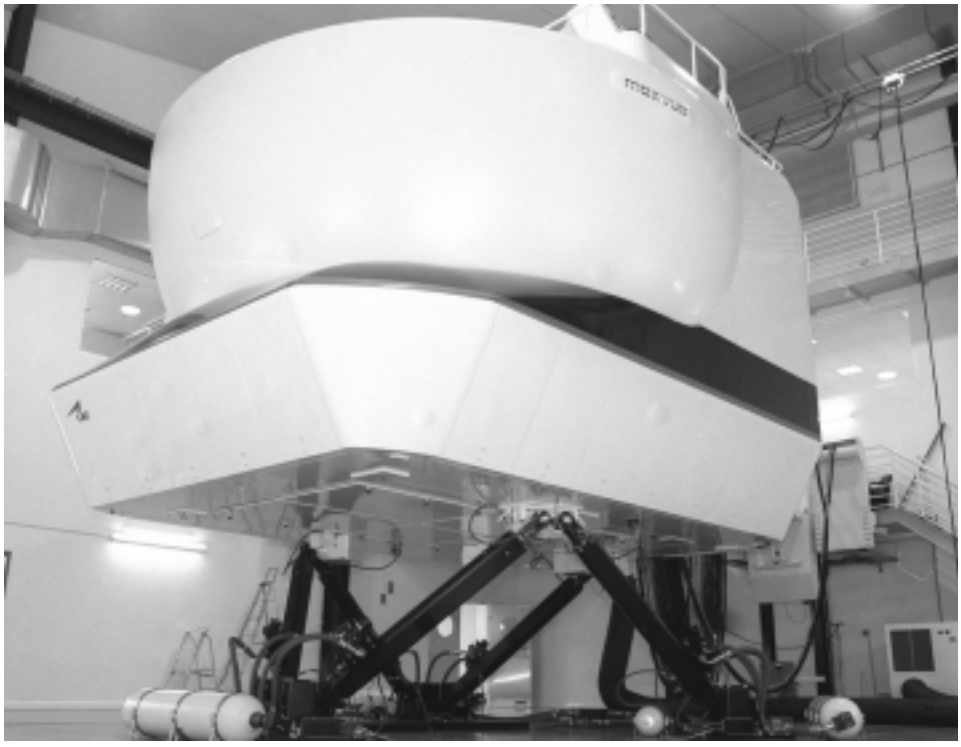
2.18 Project team skill sets also appear to have been an important positive factor for this project. Team members have brought appropriate skills to the project and made good use of opportunities provided by Defence to undertake formal studies in project management.

2.19 Defence's ALSIM Project Office and CAE Electronics include risk management plans as part of their respective project management plans for the two simulators.

2.20 For both ALSIM simulators there have been some Contract Change Proposals and some Engineering Change Proposals, which have been approved. However, none of these changes have deviated significantly from the approved scope of the projects. Most have resulted from changes to the aircraft configuration and refinement of requirements. If functional changes are made to an aircraft or its equipment that affect its operating characteristics, comparable changes may be required to any related simulator.



Exterior views of B707 simulator, showing extended movement during motion envelope testing (above) and simulator in normal position (below).



2.21 Aircraft flight data for the B707 simulator was obtained from RAAF technical publications, Boeing, aircraft parts vendors and through a flight test program. Because B707 aircraft were widely used, data are readily available. The data strategy used for this project appears sound but its ultimate effectiveness will become apparent only during testing of the simulator later this year.

Outcomes

2.22 Present indications are that this project will result in delivery on time and within budget of a high-fidelity simulator that will extend the life of the aircraft to at least 2010, increase safety and enhance aircrew training.

2.23 The ANAO notes that the lack of a TNA was a deficiency of this project.

C-130J-30 simulator

2.24 The RAAF is to acquire 12 new C-130J-30 aircraft in the near future at a project cost of $920.5 million (or $957.4 million if the simulator is included). Air Force envisages buying more C-130J-30 aircraft later (after 2005). The C-130J-30 is significantly different from the earlier versions of the C-130 — or 'Hercules' — perhaps most noticeably in terms of its technological advances including extensive computerisation. For example, it has a 'glass cockpit', in which instruments have been replaced by multi-function displays.

ALSIM project

2.25 As mentioned earlier, Defence is acquiring the C-130J-30 simulator and the B707 simulator from CAE Electronics by means of one project team — as the Air Lift Simulator (ALSIM) Project.

The decision to buy

2.26 The decision to buy a C-130J-30 full flight simulator was taken in 1994 at the same time as the decision to acquire the new aircraft.

2.27 The provision of a simulator was included in the original contract for the 12 aircraft being bought initially. This approach should have a number of advantages, including the timely training of aircrew.

2.28 Realising that the C-130J-30 aircraft would require significant aircrew training, Air Force undertook an initial TNA which indicated that the acquisition of a full flight simulator would be an effective training aid that would bring a number of other benefits including the lengthening of the service life of the C-130J-30 aircraft. This indicates prudent planning and management.

2.29 An individual cost:benefit analysis was not conducted for the C-130J-30 simulator as it was a replacement capability and was embedded in the major capital equipment development process for the C-130J-30 aircraft. It was accepted that aerospace simulators provide a clear benefit because of the reduction in flying hours. Defence estimated the cost of operating both the B707 simulator and the C-130J-30 simulator at around $454 per hour[9] per simulator, a fraction of the cost of operating an aircraft.

2.30 A list of training tasks was prepared as part of the TNA. With the simulator nearing completion, the ANAO was shown documentation illustrating how it would meet the identified training needs and could be used for additional and useful — but previously not specified — training tasks. The ANAO was informed that, with the rapid evolution of the technologies used in simulators, this situation was a welcome, but not an unusual, occurrence.

Contract management

2.31 As mentioned above, the acquisition of the C-130J-30 and B707 simulators were managed under the one Project Team. In relation to contract management, data acquisition is the only aspect requiring comment (below).

2.32 Defence obtained the data needed for the C-130J-30 simulator from the aircraft manufacturer and vendors of aerospace systems. Some difficulties have been experienced due to the developmental nature of the aircraft. The manufacturer of the simulator was to obtain the data but there were delays, primarily because the simulator manufacturer had little leverage to apply to the aircraft manufacturer, which was faced with a back log of aircraft orders.

Outcomes

2.33 Although the simulator has not yet been delivered present indications are that the simulator will be delivered on time[10] and within budget. The simulator is expected to be an effective training device that will enhance C-130J-30 aircrew training and prolong the LOT of the aircraft.

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[9] The hourly rate was calculated using the monthly payment to CAE Electronics Ltd for the management and support agreement plus an allowance for the amortisation of spares acquisition and spares repairs costs. No allowance has been included for capital write-off, depreciation or military personnel costs.

[10] Allowing for a two week delay due to a severe ice storm in Montreal where the simulator is being built.

Interior view of F-111C mission simulator. (Photograph courtesy of RAAF Amberley Photographic Section).

F-111C simulator

2.34 In contrast to the previous two simulators, the F-111C simulator is a tactical mission trainer designed for aircrew to practise tactical missions and associated combat flying activities. Training capabilities encompass a vast array of activities including action to counter simulated hostile activity from missiles, radar, other aircraft and so on. The F-111C simulator it is not a 'full flight' simulator, does not have 'motion', and is specified with only a low-fidelity graphics system. Although it provides basic flying training, it is not intended as an *ab initio* flight trainer. The simulator is being manufactured by Wormald in Australia at a cost of $44 million.

2.35 Air Force did not conduct a formal TNA for this simulator, although the ANAO was informed that there was some analysis of training needs. Without a formal TNA it is not possible to say whether the project was correctly scoped and therefore properly costed in the first place. The ANAO has been told that Air Force is now preparing a TNA for the simulator.

2.36 An Operational Directive (1989) defined a requirement for a full-function flight simulator for the F-111C. However, to gain approval for the acquisition (in 1991) Air Force was required for budget reasons to down-scope the proposal in order to reduce the estimated costs from $67 million to $44 million. As a result there will be a significant training gap between the 'down-scoped' simulator being acquired and the simulator originally proposed.

2.37 The ANAO was informed that the down-scoping involved elimination of the motion capability of the simulator and elimination of a set of flight trials intended to obtain flight performance data. In addition, the digital geographic information was confined to the requirements of dusk/night capabilities with reductions in the amount and detail of the geographic data required.

The decision to buy

2.38 Australia's F-111C aircraft have been in service since 1973 and they are presently being upgraded under a program referred to as the Avionics Update Program (AUP). The decision to acquire the new F-111C mission simulator being considered in this audit was based on the need to replace the original F-111C simulator at RAAF Amberley with a training device for RAAF Strike Reconnaissance Group (SRG) aircrew that would simulate the performance and functions of the aircraft after the AUP.

2.39 In February 1991 Defence estimated that the F-111C simulator would lead to savings of approximately $40.3 million over the LOT of the aircraft.

Contract management

2.40 The project has had four project managers in a relatively short period of time. The fourth Project Manager since contract signature in 1993 took up duty in June 1997. This had the effect of dissipating corporate project knowledge and adding to the difficulty of maintaining effective communications with contractors. It was also inconsistent with:

(a) JCPA recommendations on Defence project management, that were designed to avoid the adverse effects of high staff turnover or project team knowledge;[11] and

(b) Air Force's own project advice to Air Force Personnel Branch.

2.41 The impact of Air Force personnel posting cycles has made the management of this project unnecessarily challenging. The F-111C simulator project office recognised staff turnover as a very high risk but could not influence Air Force Personnel Branch to provide stability of staffing and appropriately experienced personnel.

2.42 An interim configuration simulator was to be delivered to RAAF Amberley in August 1996, with development work continuing at Amberley until the final configuration was achieved around June 1997. However, the August 1996 delivery date was not met and instead an interim capability simulator was delivered in January 1997. The simulator is being retrofitted on-site at Amberley to meet the complete contract requirements. In the meantime, the interim capability simulator is being used for some training purposes.

2.43 Current indications are that the final simulator will be completed at the end of the third quarter of 1999.

2.44 There is no evidence of a risk management plan for this project, although some risk mitigation measures are embedded in various engineering and test plans.[12]

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[11] See Joint Committee of Public Accounts, 1986, *Report 243 - Review of Defence Project Management* AGPS Canberra (two volumes) and Joint Committee of Public Accounts, 1987, *267th Report - Response to Review of Project Management Report* AGPS Canberra pp.13-14. *Report 243* noted (p.201) that, on a project to acquire a C-130H simulator, retention of the principal specialist during the project cycle helped to counter deficiencies in project definition and planning.

[12] Defence advised that the F-111C simulator project has a risk register maintained by the contractor.

2.45 Equipment acquired for defence purposes is often more highly specified than that used by civilian organisations as it needs to be highly reliable in the abnormally rugged and demanding operational conditions that military operations often entail. For this reason much military equipment is built to specifications referred to as 'military specifications'. Simulators, however, do not operate under such harsh conditions and their components do not necessarily require such high standards of reliability. Failure of a simulator component does not carry the same risks as the failure of an aircraft component.

2.46 Components of the F-111C simulator were built to 'military specifications', with Military Standard 2167[13] and engineering Design Authorised Contractor (DAC) requirements being applied to the project. The ANAO considers that any proposal to build simulator equipment to costly military specifications should be pursued only after considering a sound business case for doing so.

2.47 The ANAO was informed that not enough data exist for this simulator to be able to achieve high-quality flight-handling and hence flight-training capabilities. Furthermore, mature aircraft systems data were delivered later than expected, causing some problems. The project has been complicated by the need to include simulation of the latest aircraft configuration under the F-111 AUP. Data from the modifications under the AUP were difficult to obtain in a timely manner — due to slippage of the AUP and the sensitivity of some of the data — with consequent difficulties in obtaining the data for the contractor. The ANAO considers that a systematic risk management plan would have helped avoid this delay, although Defence considers that delay was inevitable because of the AUP.

Outcomes

2.48 The expected outcome is a simulator that will significantly enhance the mission training capability of Strike Reconnaissance Group F-111C aircrews.

2.49 The original contract required delivery of the completed simulator to coincide with the delivery of the 21st aircraft under the AUP. Due to AUP slippages the 21st aircraft will not be delivered until August 1999. In 1996 the simulator contract was altered to reflect a date-based rather than an event-based completion target. By the original AUP-linked schedule the simulator project is presently running about two months ahead of the original schedule. However, by the current revised date-based schedule there has been a slippage of some 25 months in the projected completion of the simulator.

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[13] Also referred to as DOD-STD-2167.

2.50 In summary, the management of this project could have been improved by conducting a formal TNA at the start of the project, avoiding high staff turnover during the project and managing the project in accordance with a systematic risk management plan.

Black Hawk simulator

2.51 The Army's Black Hawk helicopter acquisition project commenced in 1986. However, it was not until much later (November 1993) that Army made a case to acquire a Black Hawk simulator. The case was based on a training need and the need to release aircraft committed to training purposes. The full flight and mission simulator is expected to be fully operational by January 2000.

The decision to buy

2.52 When the ADF bought Black Hawk helicopters in 1986 it did not buy a simulator for them.

2.53 Once the Black Hawk helicopters were in operation Army experienced problems in the training of pilots. Army also found that aircraft needed for operational purposes were unavailable because they were being used for pilot training purposes. These factors, and the training and financial advantages of simulators, drove the need to acquire a high-fidelity full-flight and mission simulator that could be used to train aircrew and release aircraft for operational purposes.

2.54 The simulator is being built by CAE Electronics in Montreal, Canada, at a contract price of $28.1 million for the simulator, $3.7 million for a facility to house it, and $6.9 million for five years of management support and replaceable items. A Black Hawk helicopter costs around $6 300 per hour to fly.[14] The simulator will cost around $480 per hour to 'fly'.

2.55 The acquisition of a full-flight and mission simulator for the Black Hawk helicopters was justified on the basis of training needs and the need to release aircraft for operational purposes. The simulator should also extend the LOT of the aircraft.

[14] This is the direct cost (ie, fuel, oil, parts and so on). The full recovery cost is $13 045 per hour, which includes such items as personnel and facilities.

2.56 Although the acquisition of the simulator was based in part on training needs there is no evidence of a formal TNA being conducted prior to the acquisition. In the absence of a TNA, functions that the simulator would need to perform were specified without linking those functions to assessed training needs. This has left Defence exposed to the risk of the delivery of a simulator that satisfies the original contract specifications but not training needs, as the latter were not defined prior to tenders being called.

Contract management

2.57 Staff turnover in Defence's Black Hawk simulator project office has made it difficult to manage this acquisition contract. An entirely new project management team was established immediately prior to project approval early in 1994 and the project has had two Project Directors and three Project Managers.

2.58 A risk management plan for the project was prepared but not endorsed prior to contract signature. In response to the proposed report of this audit, Defence advised in October 1998 that the Black Hawk simulator project now has a risk management plan.

2.59 The aim of this project is to acquire an effective sophisticated training device costing $31.8 million and for which the means of simulating with high-fidelity the required low-level hovering flight and attendant large collimated[15] field of view had not been developed at the time of contract signature. The ANAO notes that Defence embarked on this project with at least three handicaps; that is, there was no formal TNA; there was no endorsed risk management plan; and there has been a high turnover of key staff.

2.60 Defence acquired flight performance data required by the simulator contractor, but obtaining that data took longer than originally estimated. Additional flight performance data were acquired at the Aircraft Research and Development Unit (ARDU) at Salisbury, South Australia.

Outcomes

2.61 The outcome of the project in 2000 is expected to be a high-fidelity training simulator that will enhance Black Hawk aircrew training, release three Black Hawk helicopters from training activities and save some 1 445 flying hours per annum (equivalent to $8.4 million per annum in present day prices).

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[15] Collimation is where the image is focussed at infinity thereby providing what is, in essence, a real world scene. The ability of crew members to perceive images in their correct location is one of the outcomes of a collimated image.

2.62 The project is running some 13 months late which, in terms of the cost of flying hours the simulator was to replace, represents a cost of around $9 million. The delay has been associated with high staff turnover in the project office, development of the visual display and acquisition of flight data. Furthermore, as noted earlier, there is a risk of the delivery of items that satisfy the original contract specifications but not original training needs, as the latter were not formally analysed before tenders were called.

2.63 In summary, the management of this project would have been improved by:

- conducting a formal training needs analysis before tenders were called for the simulator;
- preparing and endorsing a risk management plan; and
- avoiding or at least minimising high staff turnover on the project team.

Outcomes from the four projects

2.64 The outcomes of the four simulator acquisitions varied. The B707 and C-130J-30 simulator projects are expected to lead to the delivery of useful training devices within budget and on time. The F-111C simulator acquisition should result in a significantly enhanced mission training capability for the Strike Reconnaissance Group F-111C aircrews. The Black Hawk simulator acquisition project should also result in a high-fidelity training device that will enhance Black Hawk aircrew training and release three Black Hawk helicopters from training activities. The latter project is, however, running some 13 months late. Problems encountered on the projects have tended to be associated with high turnover of staff.[16]

[16] See also comments at paragraph 2.62 of this report about delays with the Black Hawk simulator.

3. Issues arising from the audit

3.1 This chapter sets out issues arising from the audit, including the four simulator acquisition case studies, together with recommendations aimed at adding value to this general area of Defence activity.

Simulation policy and standards

3.2 The ADF does not have a comprehensive policy on aerospace simulators or other forms of simulation. This appears to be inhibiting the ADF's ability to exploit the opportunities now offered by simulation technology. A Defence simulation policy should clearly define a development strategy for simulation as well as guidelines and standards for simulation and a mechanism for coordination of aerospace and other simulation activities. Defence could benefit from having a master plan along the lines of the US *Department of Defense Modeling and Simulation Master Plan* (1995 edition) and the NATO *Modelling and Simulation Master Plan* (1998), but tailored to Australia's circumstances and requirements.

3.3 As mentioned earlier, the Defence Efficiency Review report (March 1997) commented that the Defence Simulation Coordination Group had produced a draft Defence Simulation Policy and draft Simulation Master Plan which aim to address the need for an expanded support role for modelling and simulation while providing a coordinating mechanism for the development of these tools across Defence. Neither the policy nor the master plan has been issued. The ANAO considers that they would help Defence coordinate proposals to spend $1.1 billion on simulation over the next five years.

3.4 An apparent lack of adequate awareness of the advantages offered by simulation, combined with a lack of Defence policy and standards on simulation, has led to a compartmentalised approach to simulators that has not been in the best interests of the Defence Organisation.

3.5 Given the vital nature of performance data for the effectiveness of simulators, and the way in which simulators are developing, particularly in relation to interoperability and the linking of simulators, consideration should be given to the early promulgation of Defence simulation data guidelines. Such guidelines (and any simulation policy and standards) would need regular review and updating to keep pace with developments in the simulation technologies that are available.

Recommendation No.1

3.6 The ANAO recommends that Defence promulgate a simulation policy and master plan with standards and guidelines for the acquisition of simulators, and review and up-date these documents to keep pace with developments in the simulation technologies that are available.

Defence response

3.7 **Agreed.** It is acknowledged that the simulation policy and master plans developed prior to August 1998 lacked a clear statement to guide progress in this area. In August 1998 the Defence Capability Forum discussed modelling and simulation and directed the Defence Simulation and Coordination Group to recast both documents into a single, high-level strategic plan which will inform and guide future development in this area. The revised plan is expected to be considered by the Capability Forum within six months.

Consideration of training needs and simulators when buying capital equipment

3.8 When considering the acquisition of major items of capital equipment Defence should also conduct a training needs analysis (TNA) to identify cost-effective and efficient devices (including simulators) for training personnel to operate the equipment.

3.9 A decision to acquire a simulator should be taken only after a comprehensive review of the need for the simulator including identification of the role of the simulator in a training program. That role should be identified by means of a TNA. In three of the four cases reviewed the ANAO found no documented TNA.

Recommendation No.2

3.10 The ANAO recommends that Defence, when acquiring major items of capital equipment:

(a) undertake appropriate analysis to identify cost-effective and efficient training devices (including simulators); and

(b) acquire simulation equipment only after an appropriate training needs analysis that identifies the most appropriate suite of training equipment.

Defence response

3.11 **Agreed.** Defence training policy will be amended to ensure that all future simulation proposals include a TNA.

Simulator specifications

3.12 Equipment acquired for defence purposes is often more highly specified than similar equipment acquired by civilian organisations. This is because military personnel rely on equipment that they may need to operate in abnormal conditions. Simulators are not used in abnormal conditions and their components do not necessarily need to meet such stringent and costly standards. For the F111-C simulator Military Standard 2167 and engineering Design Authorised Contractor (DAC) requirements were specified. Such military specifications add to the cost of the acquisition. The ANAO considers that any proposal to build simulators to costly military specifications should be pursued only after considering a sound business case for doing so.

Recommendation No.3

3.13 The ANAO recommends that the specifications for Defence aerospace simulators should stipulate military specifications for particular components and / or aircraft design regulation requirements only when a business case has established a need for such specifications.

Defence response

3.14 **Agreed.** Military specifications for simulators will only be used where there is a clear case supporting such an approach.

Data acquisition

3.15 Data on the operational performance and behavioural characteristics of aircraft and related equipment are important for the effectiveness of a flight simulator. The simulator contractor needs the data to build the simulator and Defence needs the data to maintain the simulator and to develop simulation. Data acquisition strategies are a crucial aspect of simulator acquisitions. The strategies used in the different projects examined varied considerably. Normally Defence has access to the necessary data and / or the leverage to obtain it — by virtue of its position as a customer — from aircraft and other manufacturers. Accordingly, Defence should play the leading role in ensuring the acquisition of data for simulation purposes although the actual work may be carried out by the prime contractor.[17]

[17] Such an approach is proposed in the paper Northam, Geoff, 1997, *Management of Design Data for Military Aircraft Flight Simulators: Adopting Strategies That Provide Commitment to Success,* Proceedings of SimTecT 97, pp.317-322, especially sections 3.1 and 3.2 (pp.318-9).

3.16 The contract for the Black Hawk simulator was let long after delivery of the Black Hawk helicopters. The original contract for the aircraft had provided that the aircraft manufacturer was to provide aircraft data for simulation purposes. However, when the time came to provide the data, the simulator manufacturer found it inadequate for the specific simulator sought, although it met the original aircraft contract requirements. The simulator manufacturer had little leverage over the aircraft manufacturer to obtain the data it needed.

Recommendation No.4

3.17 The ANAO recommends that Defence retain the principal responsibility for ensuring the acquisition of appropriate data for simulation purposes, while recognising that the actual work may be carried out by the prime contractor, under instruction from Defence.

Defence response

3.18 **Agreed,** with qualification. The issue is not simply one of data acquisition. The data must also be maintained, updated, verified, validated and assured. Defence will retain principal responsibility for data acquisition where appropriate and a strategy for acquiring appropriate data will be detailed in the project Data Acquisition Management Plan which will consider such issues as data availability and relationship to prime equipment acquisition etc.[18]

Contracts and data

3.19 As indicated above, simulators need data on the equipment to be simulated. In one of the four simulator projects, the simulator contractor relied on Defence to obtain sufficient data. Defence's aircraft contracts have not all made adequate provision for access to data. If the aircraft contract does not provide for adequate access to data, it may be difficult and costly to access later. Defence should seek access to data for simulation when it is negotiating for the acquisition of aircraft (or other major capital equipment that may be simulated for training purposes), while it is in a strong bargaining position to obtain the data.

[18] The ANAO acknowledges the points raised in Defence's response to the recommendation.

Recommendation No.5

3.20 The ANAO recommends that, when negotiating for the acquisition of major capital equipment, Defence should seek access to equipment performance data for simulation purposes.

Defence response

3.21 **Agreed.**

Risk management plan

3.22 The acquisition of any major item of simulation equipment should proceed according to an associated risk management plan. On the F-111C simulator project a risk arising from high staff turnover was foreseen but not forestalled. The ANAO found that, for that project and the Black Hawk simulator project, there were no risk management plans.

3.23 A risk management plan should describe the objectives of the project and identify possible risks to the project. It should detail actions aimed at minimising the identified risks and specify ways for monitoring, reviewing and treating risks and their possible consequences. In this context, planning, monitoring and reviewing should be ongoing processes until the project is completed.

Recommendation No.6

3.24 The ANAO recommends that Defence proceed with the acquisition of any major aerospace simulator according to an associated risk management plan prepared at the outset of the acquisition process.

Defence response

3.25 **Agreed.**

Skill sets and contact with contractors

3.26 The ANAO noted the more effective contact with the contractor on the ALSIM Project (for two simulators) than on the F-111C and Black Hawk simulator projects. In response Defence acknowledged that face-to-face contact has assisted the ALSIM Project but noted that the other two simulator projects also have regular face-to-face meetings with the prime contractor and that both projects maintain a resident office at the contractors' premises.

3.27 The ANAO notes that the simulator projects examined demonstrated the advantages of regular face-to-face communications between appropriately qualified and experienced project staff and the contractors involved. They also reinforced the need to have the right experience in project management and to retain skills appropriate to the project. Where this occurred in the cases examined (the ALSIM simulators), the relationship between the contractor and the Department was more productive, the process of acquiring the simulator has been generally smoother and the final outcome more satisfactory for the Commonwealth.

3.28 The ANAO was advised during the audit that the formation of a dedicated Simulator Project Environment (SIMPE) within the Defence Acquisition Organisation (DAO) Aerospace Acquisition Division (AAD) should result in positive developments in this area. Most Defence aircraft simulator projects will be managed from SIMPE, and Defence expects that this will result in a 'centre of excellence' in aerospace simulator project management.

3.29 The ANAO notes that Defence has taken specific steps aimed at maximising continuity in both leadership and in corporate knowledge of aerospace simulator project teams.

Staff turnover

3.30 In 1987 the JCPA identified 'low retention of project knowledge due to a high staff turnover' as one of the 'several structural deficiencies in the Department's approach to project management'.[19]

3.31 High staff turnover continues to be a cause of serious problems for some projects. For example, the Black Hawk and F-111C simulator projects have had seven project managers between them in a total of seven project-years.

3.32 On the ALSIM Project for the B707 and C-130J-30 simulators the ANAO found that Defence had made some improvements along the lines of the JCPA's recommendations following its Review of Defence Project Management. Those improvements included such matters as consistency in project management, retention of key project management skills and development of career paths in project management. In contrast, the ANAO found that the F-111C simulator project and the Black Hawk simulator project suffered from problems associated with high staff turnover.

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[19] Joint Committee of Public Accounts, 1987, *267th Report, Response to Review of Project Management Report,* AGPS, Canberra, particularly pp.13-14.

3.33 The ANAO notes that the establishment of the SIMPE should help alleviate problems that have occurred in the past through high staff turnover on aerospace simulator projects.

Configuration management

3.34 Even during construction of the four simulators it was found necessary to change their functional characteristics to reflect changes arising from aircraft modifications and upgrades. Concurrent action of this kind has not always occurred. A recent internal Defence survey disclosed that a high proportion of the Department's training simulators suffered from deficiencies and had never been upgraded.

3.35 When an aerospace simulator no longer accurately represents the aircraft, its value for training is reduced and may become negative. Those responsible for aircraft and those responsible for simulators both need to be alert to ensure that simulators are changed as necessary to reflect aircraft modifications and upgrades.

3.36 A simulator can also lose its training value over time as continued use causes wear and tear to simulator instruments and controls. This calls for configuration management and recurrent fidelity checks to help ensure that simulators continue to represent aircraft functional characteristics. Associated with this is a need periodically to check the integrity of the relationship between the simulator, the intended training purpose and the aircraft. These issues are particularly important for aerospace simulators.

Recommendation No.7

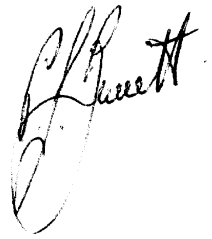
3.37 The ANAO recommends that, to help keep aerospace simulators at their full training capability, Defence:

(a) ensure that, when aircraft are modified or upgraded in a way that changes their functional characteristics, corresponding changes are made to the functional characteristics of any simulators for the aircraft; and

(b) establish simulator configuration management procedures for recurrent fidelity checks to confirm that simulators are maintaining their proper functional characteristics.

Defence response

3.38 **Agreed,** with qualification. Defence supports this recommendation noting that only so much can be done within available resources and overall Defence priorities.



Canberra ACT
25 November 1998

P. J. Barrett
Auditor-General

Appendices

Appendix 1

Simulator developments and reviews

Background

1. The field of simulators — and modelling and simulation (M&S) generally — is changing rapidly and some appreciation of recent developments in this area will help place the acquisition of aerospace simulators in context. This appendix has been included in the report specifically for this purpose.

2. Historically, the concept of a device like an aerospace simulator had its genesis over seventy years ago. In 1924 Reid and Burton[20] noted the potential value of a device which would represent the behaviour of an aircraft in flight on the ground.

They concluded[21] that such devices, if they could be constructed, could be used to:

1) test the ability of subjects to fly and land successfully

2) assess the rate of acquisition of flying skills

3) train pupils on those particular coordinations necessary for aircraft control

4) classify subjects for different forms of flying service.

3. As components of rapidly evolving and developing information technologies, modelling and simulation are developing fast and offer many new opportunities for the ADF. Elements of the Defence Organisation are aware of this. The ANAO was shown a number of projects being undertaken by the Defence Science and Technology Organisation (DSTO) aimed at developing and maximising the benefits derived from modelling and simulation.[22]

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[20] Reid, G H and H L Burton, 1924, *Psychomotor responses in relation to flying,* Proceedings of the Royal Society of Medicine, pp.17, 43-53.

[21] As reported by Rolfe, J M and K J Staples, 1986, *Flight simulation,* Cambridge University Press, Cambridge, p.13.

[22] For example, DSTO's *Takari Program* is described as 'DSTO's R&D program designed to provide the ADF with the capability to fight and win knowledge based warfare in the 21st Century.' DSTO pamphlet entitled *The Takari Program.*

4. The literature suggests that most other developed countries are exploiting modelling and simulation in the military sphere to considerable advantage. A NATO report illustrates this:

> *The Netherlands has attached considerable importance to the wider use of simulators by the armed forces. The need to alleviate the nuisance caused by aircraft on low-flying exercises, to reduce the damage to training grounds from manoeuvres and to minimize the use of shooting ranges, for example, underscores the importance of simulation techniques. Use of simulators in a training programme can not only reduce costs but also minimize environmental damage. This Netherlands-led study is surveying existing opportunities within NATO for the wider use of simulators. Participating countries are: Belgium (observer), Germany, Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, United Kingdom and United States.*[23]

5. Under certain circumstances — including interoperability[24] — there are advantages in linking simulators. Two Australian authorities have stated:

> *Sophisticated simulations which link operational and logistic support activities are in routine use in the US, UK and GDR.*[25]

6. Military simulation applications are growing particularly rapidly.[26] This activity is a direct consequence of the rapid growth of computer technologies and the development of new ways of handling[27] and using vast amounts of information.

7. The roles of information are undergoing fundamental changes within all sectors of developed countries including in military simulation. A key to effectively exploiting the new technological advancements — and gaining the 'knowledge edge' — is finding, assessing and acting on the right information in a timely manner.

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[23] North Atlantic Treaty Organization, 1995, Committee on the Challenges of Modern Society (CCMS), *Use of Simulators as a Means of Reducing Environmental Impacts Caused by Military Activities,* [Online], Available: http://www.nato.int/ccms/s03/s03.html / website http://www.isn-lase.ethz.ch/cgi-bin/isn/...ion%401%7esimulation%404%7esimul%402%7e&, [25 June 1998]

[24] 'Interoperability refers to the ability of simulations or simulators to provide services to and accept services from other simulations or simulators, and to use the services so exchanged to enable them to operate effectively together.' Clark, P. and C. Mazur, 1998, *Ten Year Australian Defence Simulation Strategy,* proceedings of the *SimTecT 98* Advanced Simulation Technology and Training Conference, 2-6 March 1998, Adelaide, p.123.

[25] Clark, P. and C. Mazur, 1998, *Ten Year Australian Defence Simulation Strategy,* proceedings of the *SimTecT 98* Advanced Simulation Technology and Training Conference, 2-6 March 1998, Adelaide, p.125.

[26] Measuring the cost-effectiveness of military simulators is a complex task. See Fletcher, J. D., 1998, *Measuring the Cost, Effectiveness, and Value of Simulation Used for Military Training,* Proceedings of SimTecT 98, *Advanced Simulation and Training Conference*, Adelaide, March 1998, pp.47-52.

[27] Including information collection, analysis, processing, storing and presentation.

8. Simulation, and simulator technology, is rapidly developing in terms of its capability to provide a means for cost-effective training and ability to contribute to the acquisition and maintenance of crucial skills in many areas of the ADF. Simulation is not a replacement for all training, but some training can be carried out only by means of simulation. Also, simulation is being used in an increasing number of military environments, which is possible through the creative combination of new technologies and new equipment, assisted by smaller, faster and more powerful computers.

9. The ANAO was advised of, and the literature describes, an overseas trend in the field of simulation to lower fidelity,[28] interoperability and more units. Often the increased number of units is linked through a common network such as a high level architecture (HLA) which in turn provides a significantly increased training capability that is often also closer to 'the real thing'.

Revolution in Military Affairs (RMA)

10. The Defence white paper Australia's Strategic Policy states:

> *The so-called Revolution in Military Affairs (RMA) or the information revolution — much of which is being driven by commercial developments in the civil sector — is changing the nature of warfare all over the world.*
>
> *But for Australia it has particular significance. Not only will new technology provide military personnel with an expansive breadth and depth of information about the battlefield, but sophisticated strike weapons will give advanced forces the capability to destroy targets with an unparalleled degree of precision and effectiveness.*
>
> *Our ability to use and manage information technology will be one of the areas where we can maintain and aspire to continuing excellence. Advances in technology will put a premium on the skills of our people. We will give a high priority to investments to ensure that our military forces gain the greatest advantage from developments in this field.*[29]

11. The effective use of simulators — which is part of the RMA — depends on the ability to use and manage the new technologies strategically. The efficient acquisition and use of simulators could materially assist the Defence Organisation to achieve the objectives set out above and achieve a number of other desirable outcomes at the same time.

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[28] It is understood lower fidelity is often found to be adequate for training with simulators that can be linked and used in combined exercises.

[29] Department of Defence, *Australia's Strategic Policy,* p.55. Commonwealth of Australia 1997.

Modelling and simulation in the USA and UK

12. The Defense Modelling and Simulation Office (DMSO) was set up by the US Department of Defense in 1990. DMSO was created due to a recognition that:

> *...the field of M & S was marked by fragmentation and limited coordination across key communities (eg, across Service lines and across functional communities).*[30]

13. A report from the US General Accounting Office (GAO) gave information on simulation for just one Service, the Army:

> *The Army believes simulations are an effective tool for training its forces at many levels. Consequently, it is developing and acquiring new simulators to meet its goal of moving to a simulation-based training strategy. Between fiscal years 1993 and 1997, the Army expects to spend about $750 million to acquire simulators and another $400 million on simulation research and development.*
>
> *The Army faces many constraints on the field training exercises that it has traditionally used to prepare its forces for wartime missions. Funding for the ammunition, fuel and maintenance required for these exercises has been reduced, and environmental concerns restrict the use of ranges and manoeuvre areas. In response, the Army has turned to simulations to supplement field training exercises. The Army estimates it will spend over $1 billion on simulations over the next 5 years.*[31]

14. Earlier (1990) United Kingdom experience is reported in a National Audit Office (NAO) report as follows:

> *In 1990 the Ministry of Defence (the Department) estimated that the 3000 or so simulators in use by the three Services had cost in excess of £450 million. The Department plans to spend £700 million on simulators over the next ten years.*[32]

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30 US Department of Defense, Modeling and Simulation Master (M&S) Plan, October 1995, p.1 of Chapter 3, *Baseline Assessment of DOD M&S.*

31 US General Accounting Office, *Army Training: Commanders Lack Guidance and Training for Effective Use of Simulators,* August 1993, Washington, DC, GAO/NSIAD-93-211, pp.1, 2.

32 National Audit Office, *Ministry of Defence: Use of Simulators in Training, London,* HMSO, 6 November 1992, p.1.

Previous Australian reviews

15. The ANAO had not previously examined simulators or simulation in the Australian Department of Defence. Reports from the US GAO[33] and the UK NAO[34] were used as reference documents as aspects of them relate directly to Australian experiences with aerospace simulators.

Defence Efficiency Review

16. The Defence Efficiency Review (DER) report of March 1997 touched on the area of M & S, and made two generalised recommendations[35] on it:

> *R14. There is a need for more advanced modelling and simulation to be applied to capability development in the ADF.*
>
> *R30. DSTO should develop further its advanced modelling and simulation capability.*

17. In response to these two recommendations a paper on advanced modelling and simulation in support of capability development was prepared by DSTO for the Defence Science and Technology Committee (DESTEC) in September 1997. In addition, a paper on ADF modelling and simulation issues was being prepared for consideration by the Defence Capability Forum. The paper was being prepared by the Capability Program and Resources Planning Division in collaboration with DSTO, the Capability Development Division and the Strategic Policy and Plans Division.

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33 US GAO *Army Training - Computer Simulations Can Improve Command Training in Large-Scale Exercises.* Report to the Chairman, Subcommittee on Readiness, Committee on Armed Services, House of Representatives (January 1991). US GAO *Army Training: Commanders Lack Guidance and Training for Effective Use of Simulators* (August 1993).

34 National Audit Office, *Ministry of Defence: Use of Simulators in Training,* London, HMSO, 6 November 1992

35 *Future Directions for the Management of Australia's Defence: Report of the Defence Efficiency Review,* 10 March 1997, Department of Defence, Canberra, pp.80 and 84 respectively.

Appendix 2

ADF aircraft types for which simulators are being acquired

This appendix sets out brief background information on four ADF aircraft types for which simulators are being acquired.

RAAF Boeing B707 aircraft

1. The RAAF's 33rd Squadron operates five Boeing 707-338C long-range VIP transport aircraft which form part of the Air Lift Group. The B707s are to provide a capacity for the transport of military personnel. They also provide air-to-air refuelling capability for Australia's F/A-18 Tactical Fighter group, which increases the range of Australia's F/A-18 front-line fighters from bases in Tindal and Williamtown.

2. Boeing 707s are reliable and were formerly commercially popular, with many being brought into service throughout Australia. The ANAO was advised that RAAF's use of these aircraft over the years has involved the incorporation of many modifications which make the use of commercially-available simulators unsuitable. These modifications (combined with the deficient existing simulator) make a specialised B707 simulator necessary for the continued use of the aircraft to extend their LOT date. RAAF has also acknowledged that economic factors preclude a replacement for the B707 in the short term.

3. RAAF has acknowledged that the existing B707 simulator has not been maintained and updated to provide 'realistic' training, and is capable of providing only 'limited training value'. This was recognised in a recent Board of Inquiry (BOI) investigation into the fatal accident of a RAAF B707. In the review of the accident, aspects of aircrew training were identified as deficient. The report noted 'Contributing to the causes of the accident were the existence of several factors ... the lack of fidelity of the RAAF B707 simulator in the flight regime in which the accident occurred.'[36]

4. Defence advised the ANAO that it had achieved economies and efficiencies in 'joining' the C-130J-30 simulator project with the B707 simulator project. These projects have similarities (such as the same contractor) and address part of the training needs of the Air Lift Group of the RAAF.

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[36] Directorate of Flying Safety, RAAF, 1994, *Review of Boeing 707 Accident near RAAF Base East Sale on 29 October 1991,* Canberra, p.iv.

RAAF C-130J-30 aircraft

5. C-130 'Hercules' type aircraft have been the backbone of the RAAF's air lift and transport capability since 1958, with three different models being used in that time.

6. In 1978 the RAAF's No. 36 Squadron took delivery of the C-130H model aircraft which replaced the C-130A model.

7. No. 37 Squadron will take delivery of 12 of the C-130J-30 model 'Hercules' (now due July 1999) which incorporate new engines and significant computerisation in its design and functions. These aircraft will replace the RAAF's C-130E aircraft. The C-130J-30 is an extended fuselage version of the C-130J model. The extensive computerisation, differing instrumentation and changed performance characteristics of the new model have justified the acquisition of a C-130J-30 simulator.

8. Currently 24 'Hercules' aircraft are stationed at RAAF Richmond. The 'Hercules' aircraft are known for their reliability and long life. The older 'Hercules' aircraft in RAAF's existing fleet (now over 20 years old) are experiencing fatigue-related problems, having often flown many tens of thousands of hours. The decision to acquire the new 'Hercules' model was considered in light of the successful experience of the RAAF with the early model Hercules aircraft.

9. The ANAO was advised that the simulator for the C-130J-30 will contribute to the LOT of the replacement aircraft by allowing 'Hercules' aircrew to perform risky and high-stress tasks (such as low-level flying, take-offs and landings) in the simulator rather than the aircraft. Training in simulators in these situations is a recognised area of high benefit in terms of aircrew training and safety, and aircraft preservation.

RAAF F-111C aircraft

10. The F-111C aircraft was introduced to RAAF Nos. 1 & 6 Squadrons in 1973, and is possibly the best-known of Australia's modern jet-propelled military aircraft. The roles of the F-111C are to enable the RAAF to provide effective strike, reconnaissance and mission capability for Australia's airborne defence. In 1996 No. 6 Squadron received fifteen F-111G aircraft from the United States Air Force (USAF), which were acquired by the RAAF to extend the LOT of the F-111C by spreading flying hours across a larger fleet. The F-111Gs were purchased at an advantageous price due to the USAF's decision to retire their F-111 fleet by June 1998.

11. The indicative annual costs of operation, maintenance, fuel and staff for the F-111 aircraft platform is $244 million per annum.[37]

12. An F-111C simulator was commissioned into the RAAF, at Amberley, in 1968, to assist in aircrew training. However, due to technological limitations prevailing at the time, that simulator was without out-of-the-cockpit visual simulation and achieved a low level of handling performance. That simulator was also complex in its design and difficult to operate and maintain.

13. The F-111C squadrons are being upgraded to Post AUP configuration, which greatly enhances their capability as the RAAF's 'mainstay' in the strike and reconnaissance category.

14. It has been noted that there are major differences between the aircraft which were built in the late 1960s and the reworked aircraft: the first Post AUP aircraft became operational in 1996. The estimated LOT of the existing F-111C has been stated by Defence as to the year 2020. The simulator is expected to meet training needs to a significant level, especially in relation to the roles performed by No. 1 Squadron, which focus at the operational and tactical levels of combat.

Army Black Hawk helicopters

15. The Black Hawk is a combat troop lift helicopter designed primarily for land defence purposes. The Army currently operates 36 Black Hawk helicopters. The operations component is based at Townsville. The training courses are undertaken at Oakey, Queensland. These helicopters are an essential element of the mobility assets necessary for land force units to prosecute a land battle. Six of the Black Hawk helicopters are primarily used for training purposes — aircrew conversion and refresher training.

16. Army has recognised that there have been significant problems in the training of aircrew for the Black Hawk helicopter fleet. The view at the time of the delivery of the helicopters was, broadly speaking, that helicopter simulation was not of a sufficient standard to justify the inclusion of a simulator for aircrew training. Real aircraft were to be used for training purposes. After the purchase of the aircraft, Army reconsidered its position and decided to purchase an up-to-date Black Hawk simulator.

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[37] Answer to Question No. 419, *Defence Equipment: Annual Costs,* Australian Senate Hansard, 6 May 1997, AGPS, Canberra, pp.2775-76.

17. The decision to purchase the simulator was made in light of estimates which would see increased benefits for the Army's Black Hawk fleet. A realistic simulator would increase training for aircrew — in a safe environment — while also leading to benefits, such as decreased airframe fatigue and longer life, for the Black Hawk aircraft.

18. The Australian model is unique in the wide variety of 'Black Hawk' helicopters.

Appendix 3

Performance audits in the Department of Defence

Set out below are the titles of the ANAO's performance audit reports in the Department of Defence tabled in the Parliament in recent years.

Audit Report No. 5 1993-94
Explosive Ordnance

Audit Report No. 11 1993-94
ANZAC Ship Project - Monitoring and Contracting

Audit Report No. 19 1993-94
Defence Computer Environment
Supply Systems Redevelopment Project

Audit Report No. 27 1993-94
US Foreign Military Sales Program (follow-up audit)
Explosives Factory Maribyrnong

Audit Report No. 2 1994-95
Management of Army Training Areas (follow-up audit)
Acquisition of F-111 Aircraft

Audit Report No. 13 1994-95
ADF Housing Assistance

Audit Report No. 25 1994-95
ADF Living-in Accommodation

Audit Report No. 29 1994-95
Energy Management in Defence
ANZAC Ship Project Contract Amendments
Overseas Visits by Defence Officers

Audit Report No. 31 1994-95
Defence Contracting

Audit Report No. 8 1995-96
Explosive Ordnance (follow-up audit)

Audit Report No. 11 1995-96
Management Audit

Audit Report No. 17 1995-96
Management of ADF Preparedness

Audit Report No. 26 1995-96
Defence Export Facilitation and Control

Audit Report No. 28 1995-96
Jindalee Operational Radar Network (JORN) Project

Audit Report No. 15 1996-97
Food Provisioning in the ADF

Audit Report No. 17 1996-97
Workforce Planning in the ADF

Audit Report No. 27 1996-97
Army Presence in the North

Audit Report No. 34 1996-97
ADF Health Services

Audit Report No. 5 1997-98
Performance Management of Defence Inventory
Defence Quality Assurance Organisation

Audit Report No. 34 1997-98
New Submarine Project

Audit Report No. 43 1997-98
Life-cycle Costing in the Department of Defence

Audit Report No. 2 1998-99
Commercial Support Program

Audit Report No. 17 1998-99
Acquisition of Aerospace Simulators

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Series Titles

Titles published in the financial year 1998-99

Audit Report No.1 Performance Audit
Corporate Governance Framework
Australian Electoral Commission

Audit Report No.2 Performance Audit
Commercial Support Program
Department of Defence

Audit Report No.3 Performance Audit - Follow-up
Assessable Government Industry Assistance
Australian Taxation Office

Audit Report No.4 Performance Audit
Client Service Initiatives
Australian Trade Commission

Audit Report No.5 Performance Audit
Commonwealth Agencies' Security Preparations
for the Sydney 2000 Olympics

Audit Report No.6 Audit Activity Report
Audit Activity Report: January to June 1998
Summary of Outcomes

Audit Report No.7 Performance Audit
Management of the Implementation of the New Employment Services Market
Department of Employment, Education, Training, and Youth Affairs

Audit Report No.8 Performance Audit
Safeguarding Our National Collections

Audit Report No.9 Performance Audit
Accountability and Performance Information
Australian Sports Commission

Audit Report No.10 Performance Audit
Sale of One-third of Telstra

Audit Report No.11 Performance Audit
OGIT and FedLink Infrastructure
Office of Government Information Technology

Audit Report No.12 Performance Audit
Taxation Reform
Community Education and Information Programme

Audit Report No.13 Performance Audit
Aboriginal and Torres Strait Islander Health Program
Department of Health and Aged Care

Audit Report No.14 Performance Audit
Prescribed Payments Scheme
Australian Taxation Office