

AU/ACSC/00-051/2000-04

AIR COMMAND AND STAFF COLLEGE

AIR UNIVERSITY

RNZAF C-130 SIMULATOR TRAINING:
THE FUTURE OF A COSTLY NECESSITY

By

Squadron Leader Tony Davies, RNZAF, MNZM

A Research Report Submitted to the Faculty

In Partial Fulfilment of the Graduation Requirements

Adviser: Lieutenant Colonel Terry R. Bentley, USAF

Maxwell Air Force Base, Alabama

April 2000

Distribution A: Approved for public release; distribution is unlimited

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE APR 2000		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE RNZAF C-130 Simulator Training: The Future of A Costly Necessity				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Air University Press Maxwell AFB, AL 36112-6615				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 56	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

Disclaimer

The views expressed in this academic research paper are those of the author and do not reflect the official policy or position of the US government or the Department of Defense. In accordance with Air Force Instruction 51-303, it is not copyrighted, but is the property of the United States government.

Contents

	<i>Page</i>
DISCLAIMER	ii
ILLUSTRATIONS	v
TABLES	vi
PREFACE	vii
ABSTRACT	ix
INTRODUCTION	1
Background	1
Statement of problem	2
Objective	2
HISTORY OF RNZAF C-130 TRAINING	4
The Early Years	4
The RNZAF Discovers Flight Simulators	6
Australia Leads the Way	6
Civilian Simulators in the United States	7
Budgetary Constraints	10
Reduced Flying Hours	10
Reduced Flying Experience Levels	11
Conclusions	13
THE BENEFITS OF USING C-130 FLIGHT SIMULATORS	14
Crew Benefits	15
Learning, Maintaining and Assessing Skills	15
Improved Safety	16
Cockpit Resource Management (CRM)	17
RNZAF Benefits	17
Enhanced Operational Capabilities	17
Cost Savings	18
RNZAF Safety Record and Credibility	19
Possible Future Gains	20
Conclusions	21
A COMPARISON OF C-130 SIMULATOR USERS	22

Frequency of RNZAF C-130 Refresher Training	22
Frequency of Other C-130 Operators	23
Other RNZAF Simulator Users	24
Conclusions	25
OPTIONS AND RECOMMENDATIONS	27
Key Observations	27
Options for Increasing Simulator Exposure	28
Increased Funding.....	29
Back to Australia	29
Acquiring a Simulator	32
Recommendations	32
Final Thoughts.....	33
BASIC RNZAF STRUCTURE	35
FREQUENCY OF PILOT SIMULATOR REFRESHER TRAINING.....	38
GLOSSARY	41
BIBLIOGRAPHY.....	43

Illustrations

	<i>Page</i>
Figure 1. RNZAF C-130H over Lake Wakatipu, New Zealand	viii
Figure 2. Basic RNZAF Structure	37

Tables

	<i>Page</i>
Table 1. Typical Annual Simulator Training Costs for RNZAF C-130 Crews.....	9
Table 2. Aircraft and Pilot Hours per Year.....	11
Table 3. 1987-1999 Experience Levels	11
Table 4. Comparison between RAAF and US Civilian Based Training.....	31
Table 5. Frequency of Pilot Simulator Refresher Training.....	38

Preface

Air Command and Staff College (ACSC) presents a unique opportunity to study problems associated with C-130 simulator training because of the abundance of C-130 operators in attendance from numerous countries who have been down this road before. The vast experience and knowledge base of many ACSC and Air War College (AWC) students was extensively explored during the production of this paper. I am very grateful to those who showed great patience when faced with persistent questions regarding C-130 training and operations.

The author is also grateful to many people in the Royal New Zealand Air Force (RNZAF), who answered countless correspondence regarding finance, flying hours, and current simulator-training practices. In particular, Sergeant Tony Bing spent numerous hours processing thousands of flying records and deserves special thanks. Also deserving of special mention is the Hercules Training Officer at 40 Squadron, Flight Lieutenant Ian Davie-Martin, 5 Squadron Operations Flight Commander, Squadron Leader Brett McKenzie, and the author's ACSC Faculty Research Adviser (FRA), Lieutenant Colonel Terry 'Spanky' Bentley.

While most of the conclusions within this paper are derived from measurable data, several assumptions are based on the experience of the author. With five thousand total flying hours, of which nearly four thousand are on C-130s, command experience on C-130s during the Gulf War, and a recent tour as a C-130 Flying Instructor, he has been able to witness first hand the affect that regular simulator exposure has on crew proficiency. Furthermore, he has also seen the detrimental affect caused by lack of simulator training and the inherent dangers of conducting

risky training maneuvers in the aircraft.

This paper is written to convince readers, particularly those from the RNZAF, that simulator training is a necessity, not a luxury. It aims to draw attention to the requirement for increased simulator exposure and presents ways of accomplishing these essential training needs. This paper is not about increasing the learning yield of current simulator sessions or redesigning the training syllabus. Nor does it infer that the RNZAF should restrict its C-130 operations because of simulator currency or training issues.



Figure 1. RNZAF C-130H over Lake Wakatipu, New Zealand

Source: <http://www.airforce.mil.nz/sitemap/index.htm> [Accessed: 4 March 2000]

Abstract

This paper aims to assist the RNZAF in realizing that some long-term strategic decisions are required about the future of its C-130 training. At present, there exists a disturbing trend showing pilot experience, aircraft continuation training, and simulator refresher training to be decreasing insidiously. Most of this is due to budgetary constraints, which have reduced resources to a bare minimum. The current simulator-training scheme is too expensive to yield the required minimum frequency for refresher training and new ways must be identified to enable more training for less cost.

This paper reviews the rationale for using flight simulators and then compares the RNZAF with other air forces to assess whether its C-130 pilots are fulfilling the minimum level of simulator training recommended by those countries. It examines options for increasing the frequency and quantity of flight simulator training then makes recommendations regarding the future of RNZAF C-130 simulator training. The remainder of this abstract provides a basic overview of the current simulator situation.

The RNZAF operates one squadron of Lockheed C-130 Hercules aircraft and conducts strategic and tactical air transport missions, mainly throughout the Pacific Basin and South East Asia. The fleet is relatively small, totalling five aircraft altogether. Pilots complete the majority of their training in New Zealand and are trained by RNZAF C-130 flying instructors. Before students can take to the controls of real aircraft, they must carry out extensive training in a C-130 flight simulator. Since the RNZAF does not own such a device, all C-130 simulator training is

conducted overseas.

Simulator training is an essential part of operating any complicated crewed aircraft and it allows crews to safely practice dangerous maneuvers that are too hazardous to conduct in the actual aircraft. Additionally, large cost savings are realized by substituting simulator time for real flying hours. The RNZAF has always taken advantage of both benefits, but the cost savings are offset to a large degree by having to travel large distances to get to the simulator. To this end, simulator training can only be utilised at high cost and a tendency exists to reduce such training to its absolute minimum.

Analysis of data from the last 12 years shows that pilots are spending less time in the simulator than they used to do. Furthermore, budgetary constraints have forced reductions in flying hours. Consequently, experience levels have dropped while the nature and difficulty of the flying task remained constant. With reducing experience levels, it would make sense to increase simulator training. However, this is not the case and it may be that safety is being compromised at the sake of financial savings. The problem is not unique and other air forces around the world are facing similar problems.

Part 1

Introduction

I cannot think of anything that the Secretary of Defense pays less attention to than simulators, and I think that has to be changed.

--Senator Barry Goldwater¹

Background

Flight simulators form the backbone of RNZAF C-130 training. They are an essential component of the aircraft conversion course and a vital aid in maintaining pilot and flight engineer currency. There is no alternative available that offers the training effectiveness and level of safety of a simulator. Flight simulators come at a cost however, and for a small air force, such as the RNZAF, an extremely high cost.

As budgetary constraints tighten there is a tendency to overlook the necessity of conducting simulator training for large multi-engine, multi-crew aircraft. Simulator training is often seen by those who control the budget as an expensive luxury that should be conducted on an 'absolute minimum' basis and even then, only as financial means allow. RNZAF squadrons operating the C-130 Hercules, Boeing 727, and P-3 Orion must frequently justify their simulator training requirements to the budget managers above. There are few in such positions who have previous experience on multi-engine aircraft as pilots, instructors, or unit commanders, and may not have a full appreciation of the necessity of flight simulators or the value they offer.

Unlike many comparable air forces, the RNZAF has not had an accident involving any of its large aircraft for over 33 years. This may cause a false sense of invulnerability in the hierarchy,

which leads financial staff to query constantly the frequency and quantity of simulator training² requested by operational units. It must be appreciated that this enviously impeccable safety record is built on crew experience and skills developed using flight simulators.

The RNZAF operates its C-130s in a wide range of roles, tasks, and situations, often at the edge of operating limits of the aircraft and crew. This capability and flexibility, which is crucial to achieving the mission of the New Zealand Defence Force (NZDF),³ is largely attributed to the depth of training conducted in the C-130 simulator.

Statement of problem

In 1992, the RNZAF was forced to change its established C-130 simulator training routine and consequently incurred a substantial increase in immediate and associated costs of conducting such training. From that point, there was growing concern from squadron to wing level over the declining frequency of C-130 refresher training. In 1995, the Operations Wing Commander made recommendations regarding increased funding and frequency of this training.⁴ As of mid-1999 the situation had not changed for the better and executives and training staff at 40 Squadron were still concerned about funding levels and priority given to essential simulator training.

Objective

This paper will address the issue of RNZAF C-130 simulator training, examining in particular the rationale for using simulators, and the cost and frequency of past and present

¹ Committee on Armed Services, Chairman of Subcommittee on Tactical Warfare: Development and use of Training Simulators, 26 September 1984.

²

³ The primary purpose of the NZDF is to protect the sovereignty and well being of New Zealand by maintaining a level of armed forces sufficient to deal with small contingencies affecting New Zealand and its region, and capable of contributing to collective efforts where its wider interests are involved.

⁴ Ian Brausch, SQNLDR, RNZAF, current Executive Officer Operations Wing, 14 January 2000, Sim Training Document: AKBR 4520/4 paper by Wing Commander P. Stockwell, *Simulator Training 22 January 1996*. [Internet, e-mail to the author]. *Available*: Available as e-mail from the author, t_davies@bellsouth.net.

training. It will then compare the level of training conducted by RNZAF crews with that of other C-130 operators to determine if the RNZAF follows the minimum base-line training levels recommended by other air forces. It will also examine several possible options for increasing crew annual simulator exposure and make recommendation regarding the future of C-130 simulator training.

Part 2

History of RNZAF C-130 Training

The Early Years

The RNZAF is relatively small compared with most other First World air forces. It operates an aging fleet of aircraft, purchased during a period of relative economic prosperity in the second half of the 1960s. The purchase included five P-3 Orion maritime patrol aircraft, 17 UH-1 Iroquois utility and tactical transport helicopters, 12 A-4K strike aircraft, and five C-130 transport aircraft. While somewhat old, most aircraft in the RNZAF inventory have undergone structural modernization as well as weapons and navigation system updates. Aircrews across the spectrum of roles are well trained and capable of operating these aircraft to their limits to fulfil RNZAF mission⁵ and the mission of the NZDF.

When the bulk of the RNZAF's current operational aircraft were purchased little consideration was given to acquiring any form of synthetic training apparatus. Flight simulators were available at the time but were very rudimentary in design lacking the fidelity elements which contemporary simulators possess today: realistic graphics, motion, and flight model characteristics, and tactile control feedback. More advanced models were available utilizing early digital computers for generation of primitive graphics and motion but these devices came attached with prohibitive price tags that could only be owned and operated by the more affluent air forces. With a fleet of five C-130s, it was not economically viable to purchase and operate a C-130 simulator that could provide any more value than a checklist trainer.

At this point, little was known about benefits of simulators or how to optimize transfer of training from the simulator to the aircraft. Aspects of aviation, such as cockpit resource management and crew coordination were largely unheard of and the connection between these aspects and the use of flight simulators had not yet been made. All that was needed to operate the C-130 was knowledge of aircraft systems, familiarity with checklists and procedures, knowledge of the air transport role, and familiarity with flight regulations around the world. At that time, not every co-pilot was expected to attain aircraft captaincy and the only practical way of ascertaining a pilot's command potential was to test him in the air.

In 1967 the RNZAF purchased a Redifon procedural trainer. It was a fixed-base cockpit trainer with an instrument and control layout emulating the P-3 flight deck. It was used as a checklist and emergency procedures trainer and offered little in terms of hands-on flying value. It had the capability to be reconfigured to resemble vaguely the flight deck of a C-130. Crews at 40 Squadron⁶ practiced routine and emergency checklist actions but there were too many differences in instrumentation and cockpit layout to permit more benefit. Furthermore, a significant period was needed to switch to C-130 mode and it was easier for trainees to use an actual C-130 on the flight line to synthesize the same training. Around this time, it became apparent, from observing other air forces, that major training benefits were available via more modern and realistic flight simulators.

⁵ The RNZAF mission is to maintain a well equipped, professional and effective air force that is capable of conducting air operations and contributing to achieving the NZDF's mission.

⁶ Forty Squadron is the sole RNZAF operator of C-130s and the only fixed wing air transport unit in the NZDF. It also operates two Boeing 727-100QCs. See Appendix A.

The RNZAF Discovers Flight Simulators

Australia Leads the Way

The Royal Australian Air Force (RAAF) purchased an early Link simulator along with its 12 C-130Es in 1966. The simulator was advanced for its time and while it had no visuals whatsoever it did have limited motion and a basic flight control feedback mechanism. The RNZAF trialed the RAAF C-130 simulator. Initial reviews were positive and RNZAF crews were soon using the RAAF simulator on a regular basis. The simulator, although basic, was relatively expensive to operate and required an entire squadron of maintainers and technicians to keep serviceable. The RNZAF was charged only minimal fees to use the simulator.⁷

In 1978, the RAAF took delivery of 12 new C-130H aircraft and an H model simulator of an advanced Singer-Link design using digital technology to drive full motion, dusk/night graphics. Significant differences existed between the RNZAF C-130Es and the RAAF C-130Hs, particularly in the navigation systems, auxiliary power unit, and bleed air system. The RNZAF trialed the H model simulator but felt that the differences in systems and cockpit layout were too great to offer any advantage to RNZAF crews. Furthermore, it was more expensive to operate than the E model simulator.

The RNZAF continued to train on the E model simulator up to six times per year. Pilots, co-pilots, and flight engineers on conversion course spent two weeks at the simulator and attended refresher training at least once per year.⁸ The most efficient method of using the simulator involved two crews flying a C-130 across to Australia and back on an air transport task, conducting a three-day simulator refresher in between the transits. This way navigators could

⁷ Hourly dry rate was \$200 Australian per hour in 1982. Source: NZDEF Canberra signal ref K SZ/KQU 470/2/2 of 122250Z Dec 82.

⁸ Refresher, continuation, and recurrent training are all similar. See glossary for definition.

accompany the other crewmembers in the simulator thereby enhancing the cockpit resource management (CRM) training value gained during each session.

Use of the RAAF E model simulator ended in 1988 when the RAAF deemed the simulator too unreliable and expensive to continue operating. The RAAF decommissioned the simulator and C-130E crews used the C-130H simulator instead, modifying procedures to allow for the differences between the two models of C-130. At this point, the RNZAF was forced to switch to the RAAF C-130H simulator. Unfortunately the facility was now in high demand and it operated almost around the clock with regular down time for maintenance. Because of the high demand, RNZAF training requirements had to be coordinated and booked well in advance, often with difficulties matching simulator availability to scheduled RNZAF training. The RNZAF had to remain flexible and absorb disruptions because the simulator had become a vital component of C-130 training and compromises in safety and cost would certainly arise should it be unavailable. There were no other viable alternatives in the region. The nearest equivalent models were located in the United States, operated by Hercules Flight Training Center (HFTC) in Georgia, and Reflectone in Florida.

The RNZAF persevered with the Australian simulator and the regular rescheduling of C-130 conversion courses. Many air forces around the world had conducted studies that proved the effectiveness of simulators for improving safety and saving costs.⁹ The RAAF implemented changes that placed greater emphasis on simulator training. Their utilization increased making it even more difficult for non-Australian crews to access to this valuable resource. In 1992, the RNZAF's simulator training requirements could no longer be met by the RAAF.

Civilian Simulators in the United States

⁹ The USAF and USN both conducted studies in 1981. Mayer, Benjamin George Jr., June 1981. *Determining the Training Effectiveness and Cost-Effectiveness of Visual Flight Simulators for Military Aircraft* (Monterey, California: Naval Postgraduate School), pp. 119-120. US Congress carried out a further study in 1984. United States Senate Committee on Armed Services. September 1984, *Development and Use of Training Simulators*. Washington: U.S. Government Printing Office.

HFTC and Reflectone both operate C-130H simulators but it was HFTC who eventually offered the most cost-effective package to the RNZAF. Their simulator was identical to the Australian model although by 1992 standards its level of fidelity and sophistication were less than state-of-the-art being designed around 1970s technology. The facility also housed basic checklist and system procedural trainers that were ideal for pilots and flight engineers undergoing initial familiarization and conversion to type. HFTC offered many other training resources, such as specially designed C-130 training classrooms equipped with multimedia teaching aids for the numerous C-130 systems. Although the additional features were valuable for students on conversion, they came at extra cost.¹⁰

By now, the cost of simulator training had more than doubled compared with the RAAF facilities. Crews travelled to Atlanta by airline and accommodation was hotel based. Further, each crewmember lost four working days due to travel and rest days on each journey. When factored for a number of visits made each year this accounted for many lost mandays. Nevertheless, despite the cost, training at HFTC continues to this day. Table 1 shows the costs of simulator training conducted over a 12-year period.¹¹ All costs shown are in New Zealand Dollars (NZD) and are not inflation adjusted.¹²

¹⁰ The hourly rate for the systems trainer is \$200. Ian, Davie-Martin, FLTLT, RNZAF, current 40 Sqn Training Officer, 3 November 1999, *RNZAF C-130 Simulator DCP Bids FY 99/00*, Facsimile to the author, Available from the author.

¹¹ Costs include simulator fees, airfares, vehicle rental, hotel accommodation, meal allowances, and laundry. They do not include the salaries of 40 Squadron personnel.

¹² The NZD is worth 48.9 cents U.S. as at 21 Mar 2000. Universal Currency Converter, 21 Mar 2000, *Today's Currency Update (NZD) CUSF6F438B95566*. [Internet, e-mail to the author]. *Available*: Available as e-mail from the author, tonydavies@hotmail.com.

Table 1. Typical Annual Simulator Training Costs for RNZAF C-130 Crews¹³

	CY 87	FY 90/91	FY 98/99	FY 99/00¹⁴
Simulator Used	RAAF C-130E	RAAF C-130H	HFTC C-130H	HFTC C-130H
Crewmembers Trained¹⁵				
Conversion	8	8	10	4
Continuation	27	30	17	32
Cost per Crew¹⁶				
Conversion	10,565	13,290	58,886	81,250
Continuation	6,460	8,156	25,390	38,576
Total	115,260	145,200	538,430	647,938

Three factors contribute to the increased cost of C-130 simulator training over the last 12 years: simulator fees, air fares, and hotel accommodation. These factors will be discussed further in Part 5 of this paper. For now however, it will suffice to say that changing simulator locations from RAAF Richmond to HFTC resulted in a significant escalation of costs. As a comparison, the RNZAF's Maritime Patrol Squadron, which operates P-3K Orion aircraft, has conducted simulator training at RAAF Base Edinburgh, Australia for the past 18 years. The Orion simulator training costs have also increased over the years but only a fractionally compared to C-130 simulator training.¹⁷

¹³ Source: RNZAF Air Command Operations, 25 January 2000, *DCP for C-130 Simulator Training Bids FY89-00*, Facsimile to the author, Available from the author.

¹⁴ Current financial year includes actual and forecast training.

¹⁵ A crewmember is either a captain, co-pilot, or flight engineer.

¹⁶ A crew consists of a pilot, co-pilot, flight engineer, pilot and flight engineer instructors.

¹⁷ Brett McKenzie, SQNLDR, RNZAF, current OFC 5 SQN, 13 January 2000, *No Subject*. [Internet, e-mail to the author], Available: Available as e-mail from the author, t_davies@bellsouth.net.

Budgetary Constraints

In the post Cold War environment, many of the World's armed forces have downsized, including the NZDF, which has reduced uniformed personnel numbers from 11,745 to 9,203 in the last ten years.¹⁸ Similarly, the Defence budget dropped from 1.6 to 1.15 percent of GDP (excluding capital charge) over the same period.¹⁹ Almost every area of the NZDF has been closely scrutinized for ways to train and operate more cost-effectively. Commanders at all levels are challenged more than ever with achieving their objectives with less resources. While Defence outputs and levels of capability remain constant, flying hour allocations have reduced throughout the operational squadrons.

Reduced Flying Hours

Pilots fly less frequently and achieve less hours each year than their predecessors of ten years ago. The Table 2 shows the hours allocated and flown by the 40 Squadron C-130s as well as the number of operationally qualified pilots who share the hours. Co-pilot numbers have increased through absorption as other squadrons have closed. Between 1991 and 1998 three air transport units stood down, accounting for 17 less aircraft. Overall number of pilots in the RNZAF reduced but numbers on the remaining squadrons increased. It is seen from Table 2 that over a 12-year period, the number of hours allocated to the RNZAF's five C-130s has reduced, but hours actually flown have fluctuated due to unforeseen contingencies requiring C-130 airlift.²⁰ At the same time, co-pilot numbers increased while the number of aircraft captains remained constant. Consequently each pilot, be it captain or co-pilot, receives less annual hours than before.

¹⁸ Robert Jackson, SQNLDR, RNZAF, 2 March 2000, *Info*. [Internet, e-mail to the author]. *Available*: Available as e-mail from the author, t_davies@bellsouth.net.

¹⁹ *ibid*.

Table 2. Aircraft and Pilot Hours per Year²¹

Year	Aircraft Hours		Number of Pilots		Average Hours Flown Pilot/Year ²²
	Allocated	Flown	Captain	Co-Pilot	
1987	3,050	3,030	6	8	432
1991	2,633	2,614	6	8	373
1995	2,380	2,560	6	9	341
1998	2,466	2,829	7	10	332
1999	2,450	3,001	7	10	353

Reduced Flying Experience Levels

As available flying hours decrease, pilots spend relatively less time conducting critical aircraft maneuvers such as take-offs and landings or instrument approaches in poor weather. Table 3 compares the four areas in which pilots gain experience and skill: number of hours each pilot receives per year, number of training hours, total take-offs and landings, and hours spent in the simulator. Together, these factors will yield a net combined experience gain for an average pilot. If any of the factors is reduced then it is certain that a pilot will receive less experience. By averaging the percentage of experience gained in each area for a given year, it is seen that the average pilot is receiving less experience than in previous years. The ‘Experienced Gained’ value is an arbitrary figure produced by weighting and summing three of the many areas that contribute to overall pilot experience.

²⁰ Such events include Bougainville support, the Kosovo Crisis, and East Timor.

²¹ Source: Tony Bing, SGT, RNZAF, ALIS user, 12 January 2000, *ALIS Data*, [Internet, e-mail to the author], Available: Available as e-mail from the author, t_davies@bellsouth.net.

²² For co-pilots, half of these hours are First Pilot, the other are Second Pilot.

Table 3. 1987-1999 Experience Levels²³

Year	Hours/ Pilot	CT Hours/ Pilot	Landings/ Pilot	Simulator Hours/ Pilot	Experience Gained
1987	466	33	188	16	100%
1991	373	23	188	15	86%
1995	341	14	135	14	69%
1998	354	17	144	13	71%
1999	375	15	145	13	71%

Over a period of years, the cumulative effects have reduced experience levels throughout the depth of C-130 operators in the RNZAF. Although supporting data is difficult to produce, it is the author's opinion that the experience levels of key training personnel on the unit have also decreased over the years. These crewmembers received their own training and skills during the 1991-1994 period when hours were at their lowest. Therefore, those that are now responsible for training and standardization on the unit, have less of an experience base to share with their trainees than their predecessors did in the pre-1991 period.

From the author's first hand experience it appears that as hours become scarcer it becomes more difficult to schedule and commit to CT sorties. The Squadron is often placed under considerable pressure as operational missions, which are tasked by Air Command²⁴ conflict with training sorties, which are Squadron's responsibility.

²³ Source: ALIS database, 40 Sqn Operations Officer, and Hercules Flight Commander.

²⁴ See the RNZAF Command Structure at Appendix A.

Conclusions

This section examined the background of RNZAF simulator training emphasizing the unfortunate demise of simulator training with the RAAF. The facility was relatively inexpensive and convenient for the RNZAF, but was terminated when availability became too scarce to support the RNZAF's training needs. The arrangement with HFTC is of similar training quality but comes at a far greater cost. Also examined was the concern over declining budgets and its downstream affect on flying hours, pilot experience levels, and training rates.

Part 3

The Benefits of Using C-130 Flight Simulators

Therefore, it is said that one may know how to win but cannot necessarily do so.

--Sun Tzu

In 1986, there were 500 military and civilian flight simulators in use around the world.²⁵ Today that figure has grown considerably. Over the years simulators have become more advanced and now offer extremely high levels of fidelity. Sophisticated computerised flight modelling, advanced graphics and motion systems enable many companies to substitute training on real aircraft with simulator-based training on an equivalent hour-for-hour basis. Air New Zealand's Boeing 747-400 crews complete all conversion training in the simulator gaining a full type rating with zero flight-hours.²⁶ Newly converted pilots conduct their first real landings carrying fare-paying passengers. As well as initial conversion to type, all recurrent training and biannual check flights are conducted in a simulator enabling the real aircraft to remain commercially operational.

Unfortunately, the level of realism inherent in commercial airline simulators is not available to the RNZAF for C-130 training. Both RAAF simulators used previously and the current model used at HFTC are below the standard of fidelity required to enable zero-flight-hour conversions. While flight deck representation, especially instrumentation, motion and acoustics are all very good, their shortfalls are: lack of realism in the feel of the flight controls and visual displays that only produce a 90 degree field of view to the pilots and flight engineer. Nevertheless, there is

²⁵ J.M. Rolfe and K.J. Staples, ed., 1986, *Flight Simulation* (Cambridge: Cambridge University Press), p. 1.

enough realism present to provide substantial benefits both to crews and the RNZAF. Most benefits are real and produce measurable results, however others are intangible, and their affects can only be assumed. The benefits are divided into two categories: those where crewmembers gain, and those that profit the RNZAF as a whole.

Crew Benefits

Learning, Maintaining and Assessing Skills

The operation of multi-engine, multi-crew military aircraft, such as the C-130, demands high levels of knowledge and skill. While knowledge is taught and tested on the ground, flying skills are most effectively taught in the air. The airborne environment however, often proves to be a difficult place to instruct new students. The instructor's ability to transfer skills to the student is reduced by having to fly the aircraft, monitor radios, traffic, airspace, aircraft systems, and avoid terrain and weather. The simulator offers an ideal place to develop skills because the factors listed above can be controlled and even eliminated depending on the exercise. Initial handling exercises for new C-130 students are effectively taught with the instructor pilot sitting in the seat opposite the student. As the student advances it is often better for the instructor to stand behind the student where he can better monitor student actions, control inputs, and crew coordination. This ability is particularly advantageous with students in both pilot's seats and the flight engineer position, effectively allowing the instructor to teach three students simultaneously. This method of instruction cannot be used in the real aircraft.

Maintenance of skill and assessment of particular flying exercises are effectively carried out in the simulator. It provides the ability to instantly set up or replay any situation the instructor

²⁶ David G. Wake, Air New Zealand B747-400 Second Officer, 13 January 2000, Telephone Conversation with the author.

desires and rapidly change aircraft configuration, fuel load, cargo distribution, aircraft location, weather, and many other factors. This saves valuable time and allows many more exercises to be conducted in a specific period.

Improved Safety

Probably the single biggest benefit of simulator training concerns safety. Many aircraft and crews have been lost while conducting crew training. Thankfully, this does not apply to the RNZAF C-130s, which have a perfect safety record. However, the C-130 does have inherent problems with controllability following engine failures at low speed, such as during take-off and overshoot. The C-130's engines are located well outboard from the centerline creating large thrust asymmetry in conditions requiring high power settings. This, combined with a small rudder moment due to a relatively short fuselage, makes the C-130 one of the most demanding of all multi-engine aircraft to control with an engine out.²⁷ The situation deteriorates further when two engines are inoperable on the same. Hence, crews need significant training and experience to be able to recover successfully from such an emergency.

Simulated asymmetric training however, has proven to be just as dangerous as the real case. A RAAF Boeing 707 and its crew were lost in 1992 during double asymmetric training. The three pilots on board at the time were all flying instructors and were among the most experienced pilots from within the unit. For this reason, most C-130 operators, including the USAF, RAF and RAAF now conduct most double asymmetric training in the simulator where such maneuvers can be conducted without risk. The RNZAF still conducts a large proportion of asymmetric training on the real aircraft because of limited simulator access.

There are many other emergencies and procedures, which require substantial pilot skill,

crew coordination, and familiarity in order to be performed satisfactorily. Examples are structural failures, flight control problems, high-speed aborted take-offs, wind shear, wing and fin stalls, flapless landings, aquaplaning and icy runways. The risks associated with practicing these in the aircraft are high. The simulator is an ideal platform to safely replicate and practice such emergencies where the ramifications of mistakes are insignificant. It is for this reason that each pilot conducts regular continuation training with HFTC every 12-18 months.

Cockpit Resource Management (CRM)

CRM is the team coordination between crewmembers and the interaction between the crew and aircraft systems in a multi-crewed aircraft. It is particularly important in critical flight situations and poor CRM has proven to be a major contributing factor in nearly two thirds of all aircraft accidents.²⁸ In reality, the phrase “crew error” is often nothing more than a breakdown of CRM. The simulator provides the ideal environment to learn and develop CRM skills. Crews are placed in controlled yet demanding situations where effective captaincy and crew integration are taught and evaluated far more successfully. The real aircraft is intolerant and unforgiving towards any lack of CRM.

RNZAF Benefits

Enhanced Operational Capabilities

It is in the best interests of the RNZAF to have crews that are expert and practiced in all aspects of the operation of the C-130. There are many operating procedures that would not be possible to conduct if it were not for the ability to practice such unique and unusual techniques in

²⁷ V_{MCA} for the C-130 is the lowest of all-western civilian or military transport aircraft with the exception of AWACS type aircraft.

²⁸ M. Taverna, April 1993, “Managing Human Error,” *Interavia* Vol. 48, pp. 23-24.

a simulator. These include all weather operations where crews are able to simulate operating in extremes of weather where aircraft performance, systems operation, and crew procedures differ. Also included are three engine take-offs and windmill taxi starts, which enable the aircraft to be recovered to home base when it would otherwise be unserviceable and grounded at a remote location. Overweight take-offs, which can only be conducted in extreme circumstances, also practiced in the simulator.

Through the use of a simulator, crews can be qualified in unusual operating procedures, which are able to extend the capability and flexibility of the C-130 in certain situations without posing a training risk or placing unnecessary stress on an aging fleet of aircraft.

Cost Savings

Flight training is cheaper to conduct in the simulator than the aircraft. The operating cost of a RNZAF C-130 is 2,324 NZD per flight hour for fuel alone²⁹ and is anticipated to increase markedly as world fuel prices continue their steady upward trend. The operating cost is significantly higher if Air Traffic Control (ATC) charges and other consumables, such as spares, are added. The current cost of hiring the C-130 simulator is 1,122 NZD per hour³⁰ but rises to between 2,300 and 2,550 NZD when travelling costs, accommodation and other associated expenses are added. Whenever any element of training is transferred from the aircraft to the simulator, cost savings will be realized. Furthermore, anytime training can not be conducted in the simulator it will be more costly to complete the same training in the aircraft. At present, the RNZAF has weighted C-130 training so that as much as possible is conducted in the simulator.

Not only is the simulator cheaper to operate but it is a more efficient platform for training

²⁹ Based on average fuel flow of 10740 lbs./hr at 47.6 cents per liter. Sources: ALIS, Robert Cato, FGOFF, RNZAF, 12 March 2000, *Avtur Prices*. [Internet, e-mail to the author]. *Available:* Available as e-mail from the author, t_davies@bellsouth.net.

pilots. For instance, in a single simulator session one instructor trains two pilots simultaneously. However, in the aircraft the instructor must occupy a pilot's seat and is only able to train one pilot at a time. Exercises also take much longer to conduct in the aircraft because of the transit, set up, and positioning time. In the simulator, crews are instantly able to load pre-configured scenarios, position the aircraft at will, or rapidly replay or reset any given scenarios. Thus, significantly more exercises are accomplished in any given period than in the aircraft.

Savings are also made in terms of airframe fatigue hours. The RNZAF operates one of the oldest fleets of C-130s in the world.³¹ Each airframe has a finite life in terms of flying hours and additional hours reduce airframe service life. Additional hours also incur added maintenance and support costs, especially as aircraft approach the end of their service life, as is the case with RNZAF C-130s.

In an average year, the simulator accounts for training that otherwise would require 320 flight hours to achieve. Over the last ten years, this equates to 9.4 percent of the total airframe hours flown.³² Further, the nature of flying conducted in the simulator would have a detrimental effect on fatigue index if conducted in the real aircraft. Therefore, it can be considered that use of flight simulators extends the airframe life of RNZAF C-130s by more than 9.4 percent. The net result is that reduced hours flown on training tasks enable a greater number of operational tasks to be accomplished each year.

RNZAF Safety Record and Credibility

The RNZAF boasts an impeccable safety record for its entire fleet of large multi-engine aircraft. No aircraft have been lost in any of the three units that conduct flight simulator training.

³⁰ J. Smith, current Manager SimuFlite Hercules Flight Training Center, 12 December 1999, Conversation with the author, Marietta, GA.

Although the effects of simulator training in this regard are difficult to measure, it is highly probable that they have made a significant contribution to this achievement. Very few C-130 squadrons around the world conduct such a diverse range of roles and missions as the RNZAF's 40 Squadron. Tactical operations and strategic missions are conducted in varying environments including the Gulf War, Rwanda, Somalia, Kosovo, Pacific atolls, and Antarctica to name a few. The fact that this has been achieved with zero-loss rate over 33 years adds to the credibility of the RNZAF and the NZDF.

Circuit training is becoming an increasingly annoying factor for residents who live in the suburbs around Whenuapai airfield.³³ As stated earlier, local-area-training sorties have reduced in number but the Whenuapai district is becoming an increasingly populated area. Simulators help to minimize the disturbance by reducing the amount of training conducted in the local area and preserving favor with those residents affected.

Possible Future Gains

The C-130 fleet is in the process of being fitted with self-protection systems (SPS). This includes radar warning threat receiver, missile approach warning system, and countermeasures dispensing system. While the system has fully autonomous functionality, it requires significant training to build and maintain crew proficiency with its operation. The ability to conduct training of this type in a simulator would help crews gain optimum effectiveness with the SPS without accruing aircraft hours or expending chaff and flares. At present there are no simulators equipped with similar SPS available to the RNZAF, although the Swedish Air Force is currently

³¹ Jackson P., ed., 1999, *Jane's: World Air Forces, Order of Battle and Inventories*, (Surrey, UK: Jane's Information Group Ltd. Surrey).

³² ALIS shows that CT sorties account for 9.4% of recorded aircraft hours from 1990-99.

upgrading its C-130 simulator with SPS training equipment in order to make its own savings.³⁴

RNZAF C-130s regularly conduct fighter evasion and defensive maneuver training against strike aircraft. This type of training is particularly strenuous on the aircraft and has a large bearing on aircraft fatigue. Presently, the author is not aware of any C-130 simulators equipped to offer such a capability. However, the advantages in savings of flight hours and aircraft fatigue are significant should one become available.

Conclusions

This section examined the rationale for using simulators and their importance to the RNZAF. Benefits are gained by substituting simulators for real aircraft in particular areas of flight training. The most significant benefits are safety, training effectiveness, and cost savings. Ultimately, such benefits reflect on the capability and credibility of the RNZAF and are in its best interest to pursue. The next section will examine the extent to which the RNZAF fosters this interest.

³³ Whenuapai airfield is part of RNZAF Auckland, the parent base of the RNZAF C-130s.

³⁴ Rickard Nyström, Maj., SwAF, 12 December 1999, *Jag Tikka*. [Internet, e-mail to the author]. Available: Available as e-mail from the author, t_davies@bellsouth.net.

Part 4

A Comparison of C-130 Simulator Users

You can never get enough of a good thing. We would have saved 90 percent of our pilots during World War II if we had these simulators.

-- Senator Barry Goldwater

How much simulator training do RNZAF C-130 crews conduct each year and how does this compare with other C-130 operators? The following section examines the amount of training carried out by military C-130 crews who operate in similar roles. It also briefly looks at the training conducted by other multi-engine crews in the RNZAF.

Frequency of RNZAF C-130 Refresher Training.

From the author's experience with simulator instruction, it is apparent that crewmembers demonstrate higher levels of operating proficiency following recent exposure to the simulator. There is also a link between the frequency of simulator training and the real performance of each pilot and flight engineer throughout the year. The author also asserts that the each crewmember is more capable of handling real emergencies having recently practiced any form of simulator emergency training.

Currently all RNZAF C-130 pilots and flight engineers undergo 32 hours of simulator training during their initial conversion course. This is composed of eight sorties, each of four-hour duration. Crewmembers also conduct yearly continuation (refresher) training although the frequency is usually rather irregular. RNZAF training policy determines that each established

crew should conduct continuation training at the rate of 20 hours per year.³⁵ There are more C-130 pilots than there are established positions, and for a number of reasons this training target is rarely achieved.

Funding for these visits must compete with many other defense activities and funds are often insufficient to allow every pilot, co-pilot, and flight engineer to visit the simulator each year. Another limiting factor affecting simulator frequency is the availability of qualified flying instructors (QFIs). For reasons beyond the scope of this paper the unit is only established for two C-130 QFIs. These pilots normally occupy two of the seven established positions for aircraft captains. The sheer volume of unit training and the high tempo of operational tasking and deployments place a high workload on these instructors. Crews often conduct simulator continuation training without being accompanied by QFIs. While this is acceptable for more experienced crews it is not ideal for new crews.

The volume of exercises, short notice deployments, operational tasking, and other personnel commitments often restrict the ability for each crewmember to conduct simulator training at least once per year. The frequency has been especially affected in the last four years by the short notice and intensive involvement with NZDF contributions to situations in Bougainville, the Persian Gulf, Kosovo, and East Timor.

Frequency of Other C-130 Operators

HFTC recommends an ideal minimum frequency for pilot refresher training of twice annually.³⁶ Further, they recommend a minimum of sixteen hours at each training session. HFTC has extensive experience with C-130 simulator training and over recent years has designed a training package tailored to the preferences of customer nations that fits all crucial

³⁵ NZAP 700(S), RNZAF Manual of Policy and Planning, 1995, Edition 2, Chap 2, Annex 3.

elements of refresher training into four, four-hour training sorties.

Table 5, at Appendix B, lists a number of other C-130 operators and the average frequency at which their pilots conduct simulator refresher training. The table shows that the majority of air forces with comparable C-130 operations to New Zealand conduct refresher training twice per year. This is double the frequency of the RNZAF, which presently aims to conduct refresher training once every 12 months. However, for reasons discussed above, the actual average frequency of RNZAF refresher training at present is once every 14 months. It is also evident from Table 5 that the majority of operators listed prefer to conduct their training in blocks of 16 hours. Those countries that conduct smaller blocks compensate through increased frequency of visits. From the author's experience with simulator instruction two blocks of eight hours per year yields greater training benefit than one sixteen hour block. Although for the RNZAF one 16-hour block of four sorties is the most cost-effective method of covering all elements of continuation training and evaluation. Table 5 also shows that air forces with larger numbers of C-130s operate their own simulators. Viability of simulator ownership is discussed in greater depth in the next section but is usually a luxury that only the larger air forces can afford.

Other RNZAF Simulator Users

Apart from the RNZAF's C-130 Flight, five other RNZAF units make use of simulators. Boeing 727 crews use the United Airlines training facility in Denver, Colorado. United Airlines subsidizes the travel, which is able to reduce costs significantly. Each pilot and flight engineer attends simulator refresher training twice per year in blocks of eight hours. This is an interesting fact considering that the RNZAF 727s and C-130s are co-located in the same squadron, and both conduct simulator training in the United States. Further, the nature of flying conducted by the

³⁶ J. Smith, HFTC.

B727 is narrower than that of the C-130, and the B727 is a far more reliable aircraft, particularly in terms of propulsion malfunctions. Perhaps cost is the driving factor that distinguishes the frequency of both type's simulator training?

The P-3K Orion squadron is co-located on the same base as the C-130s. Its crews also conduct refresher training more frequently than C-130 crews. As discussed in Part 2, Orion simulator training is conducted through the RAAF in a very cost effective arrangement similar to that used by C-130 crews prior to 1992.

RNZAF Iroquois pilots make use of the United States Army simulator in Fort Lewis, Seattle. Each pilot trains once per year, saving the squadron an estimated 200 hours of actual aircraft flight.³⁷ Fourteen Squadron operates the Aermacchi MB-339CB fighter lead-in trainer and has its own fixed-base mission trainer. Squadron pilots have nearly unlimited access to this device. Seventy Five Squadron has a Skyhawk part task trainer. It is a basic simulator intended to familiarise pilots with the use of navigation and weapons systems as well as developing basic skills in air-to-air and air-to-ground tactics. It is of a fixed base design with limited graphics and has no control feedback. Again, Skyhawk pilots are in the envious position of having virtually unlimited access to this simulator.

Conclusions

The analysis above shows that RNZAF C-130 crews receive less simulator training than their counterparts from other air forces. Even crews who operate different multi-engine types in the same squadron receive more training. Is the justification for frequency of simulator training greater for 727s and Orions than it is for C-130s? Alternatively, is the frequency linked to cost,

³⁷ MacPherson, Ian, SQNLDR, RNZAF, former Training Officer 3 SQN. 24 January 2000. *No Subject*. [Internet, e-mail to the author]. *Available*: Available as e-mail from the author, t_davies@bellsouth.net.

considering that crew for crew, 727 and Orion simulator training combined is still cheaper than C-130 simulator training? If the cost of conducting C-130 simulator training is limiting the time available for each pilot then other less expensive options must be explored. The next section will examine the costs of different training options in greater detail.

Part 5

Options and Recommendations

I have yet to meet a pilot who mastered the simulator but could not fly the airplane.

-- J. McClellan, *Flying Journal*

Before examining several possible options regarding future simulator training, this section will re-familiarize the reader with the main points made in the previous sections. The paper will then conclude with four recommendations concerning the future of RNZAF C-130 simulator training that could reduce costs while helping to increase the frequency of visits and time spent in the simulator.

Key Observations

The previous sections have made several significant observations. The first is that the level of total flying experience gained by each crewmember is decreasing each year. This experience is composed of hours flown, number of training flights conducted, and amount of training accomplished in the simulator. Reducing C-130 flying hours and lack of aircraft availability often force training sorties to compete with operational tasking and, as a percentage, less training sorties are being flown each year. Additionally, pilot numbers at 40 Squadron have also risen over the last 12 years further diluting the hours available for each pilot. It is possible to supplement flying experience by increasing the amount of time spent in the simulator, but this option is yet to be realised and pilots are completing less time in the simulator each year.

Flying simulators make a significant contribution to flight safety and are a necessity in this

regard. Flight safety studies have shown that increased frequency of exposure to simulator training reduces aircraft accident rates, particularly in multi-crewed aircraft.³⁸ Many accidents are caused during training sorties when crews practice maneuvers that carry high elements of risk.³⁹ Simulators provide crews with the ability to train for difficult emergencies without any risk. However, because of limited simulator access, RNZAF crews still regularly practice maneuvers in the aircraft that have been significantly restricted by other air forces.

Flight simulators can save costs if used effectively. Hour for hour, the C-130 simulator is cheaper to operate than the aircraft. The simulator also allows many more exercises to be conducted in a specific period because of the ability to setup any required scenario quickly. There are certain exercises that can only be flown in the real aircraft, but the simulator does offer a very safe and efficient method of training in many other areas.

The RNZAF does not conduct as much C-130 simulator training as other air forces because of limited financial resources. Of the C-130 operators compared in this paper, only the Royal Saudi Air Force conducts less. The majority of other operators carry out individual refresher training twice per year in 16-hour blocks. RNZAF C-130 crews visit the simulator less than once per year. Even the RNZAF's Orion and Boeing 727 crews conduct refresher training more frequently although their costs are much lower. The downstream effect of lack of simulator currency on proficiency is evident to 40 Squadron executives and has been since 1995.⁴⁰

Options for Increasing Simulator Exposure

As flying-hour allocations decrease with a combined drop in experience levels, simulator

³⁸ Committee on Armed Services, Chairman of Subcommittee on Tactical Warfare: Development and use of Training Simulators, 26 September 1984, p. 4.

³⁹ The Aviation Safety Network database contains many examples of accidents that occurred during emergency training maneuvers. ADDRESS: <http://aviation-safety.net/> [Accessed: 13 December 1999].

training takes on more importance. The fact that the RNZAF has had nearly 34 years of accident-free multi-engine operations is no reason to ignore this issue. Many air forces have made a correlation between simulator frequency and flight safety and have increased training in this area.⁴¹ There is growing concern among 40 Squadron's training staff about low funding levels and the low frequency of refresher training. Greater priority must be given to the future of this essential activity and several options are presented below for the RNZAF to consider.

Increased Funding

The most obvious method of increasing simulator time is to increase funding. This is not as simple as it seems as simulator funding is not directly linked to operating costs and must compete with other NZDF activities for scarce funds. The implications are that as funding levels drop essential simulator training may be foregone. This is far from ideal if safe operating standards are to be maintained.

Based on the average throughput of crews at 40 Squadron, 647,938 NZD⁴² are required annually to sustain a minimum conversion and continuation frequency of once per year. Approved funding for the 98/99 financial year was 538,430 NZD and minimum refresher goals were not met for each pilot. Funding to enable each pilot to conduct refresher training twice per year, as well as normal conversion quantities will require funding of 956,546 NZD. At present, the RNZAF cannot afford to increase funds to achieve this level of training unless a cheaper simulator option is identified or funding is reduced in other areas.

Back to Australia

⁴⁰ Ian Brausch, 14 January 2000, RNZAF File AKBR 4520/4 Paper on Simulator Training, 22 January 1996. Copy available from the author.

⁴¹ Brian Walters, July 1994, "Flight Simulation: A Safe Way to Hone Skills," *Asian Defence Journal* Vol. 78, pp 31-33.

⁴² Figure based on eight co-pilots and crews visiting the sim in groups of two and conversion training for two captains, four co-pilots and four flight engineers.

The RAAF commenced taking delivery of 12 C-130J aircraft in 1999. Their purchase also included a System Familiarization Trainer (SFT) and acquisition of a full-flight mission simulator. Because of significant differences between the C-130J and previous models of C-130 operated by the RAAF, C-130J crews can not use the existing H model simulator for training. This will result in decreased workload for the RAAF C-130H simulator to the levels maintained before 1992. The resulting excess capacity could provide an opportunity for the RNZAF to recommence simulator training with the RAAF, as it did before 1992.

The C-130H simulator at RAAF Richmond offers advantages for the RNZAF over the US based simulators. Because the facility is located on a military base, crews can be accommodated in military lodgings at minimal cost. This also negates the need for meal expenses and rental vehicles. The close proximity of the simulator to New Zealand further reduces the cost because military transport can usually be used in at least one direction. The final cost reducer is the leasing price of the simulator, which is 37 percent of the HFTC model.⁴³ The sole disadvantage of using the RAAF simulator is that the facility does not have a systems procedural trainer or multimedia classroom as discussed in Part 2, however this is not an essential requirement.

The Table 4 displays associated costs at both locations for a standard continuation-training package⁴⁴ of two crews, each with four sorties of four-hour duration.

⁴³ RNZAF Air Command DCP bids FY 89/90 and 99/00.

⁴⁴ A package consists of two captains, two co-pilots, two flight engineers, and an instructor pilot or flight engineer.

Table 4. Comparison between RAAF and US Civilian Based Training⁴⁵

Cost	RAAF	HFTC
Simulator Lease	12,300	34,442
Air Fares ⁴⁶	2,800	26,950
Accommodation ⁴⁷	0	4,149
Expenses ⁴⁸	420	9,419
Rental Vehicle ⁴⁹	0	2,192
Total	15,520	77,152
Total Travel and Recuperation Mandays	14	42

It is evident from the table above that significant financial costs and mandays can be saved by using the RAAF simulator. At best, the same continuation training conducted in Australia costs 20 percent of that done in the USA. Conversion training costs 18 percent. Manday savings of 66 percent are realized in both cases. Over the course of a typical training year these figures would translate to savings of 525,902 NZD and 144 mandays. These savings could then be used to double the pilot refresher training frequency and still have 464,000 NZD left over for use in other areas.

There are also other air forces with possible potential for spare simulator capacity. Sweden is one such country that has one simulator for only eight aircraft. Their simulator is of a type similar to that used by the RNZAF. Furthermore, the Swedish C-130 simulator is also being modified to enable crews to practice self-protection countermeasures training – possibly a feature that could benefit the RNZAF.

⁴⁵ Source: Figures compiled from RNZAF AIRCMD DCP bids for FY 89/00 to 99/00. Copies are available from the author.

⁴⁶ Civilian air travel to Australia is negated if scheduled RNZAF Trans-Tasman tasking can be utilized.

⁴⁷ Military accommodation is normally available at Richmond. Should hotel accommodation be necessary then hotel costs similar to HFTC should be added.

⁴⁸ Includes meals, laundry and incidental allowances. If hotel accommodation is used then expenses will add 3,431 dollars to the total cost iaw AIRCMD DCP bids.

⁴⁹ If hotel accommodation is required in Richmond then vehicle rental costs are similar to HFTC.

Acquiring a Simulator

Purchasing a modern full mission flight simulator is not an economically viable option for an air force with only five C-130s. With an approximate purchase price of 27 million NZD⁵⁰ and operating costs⁵¹ on top of that, amortization could never be realized unless the facility were leased to other users.

Most of the cost of simulators is in the construction and maintenance of complex hydraulic systems used to provide the motion effect.⁵² Modern computers and graphics systems are able to provide excellent levels of realism in fixed-base simulators without using motion.⁵³ These are built and maintained at a fraction of the cost of a motion-featured simulator. Similar systems are in use at the C-130 training school at Little Rock AFB and cost 215,000 NZD each.⁵⁴ Before considering the purchase of such systems, the RNZAF must be certain about the replacement plans for its current C-130s and which model it will be operating in the longer term.

If the C-130J ends up replacing the current aging fleet in the near future then an interim simulator is not a viable option. If however, the RNZAF chooses to extend the life of its C-130Hs then a fixed-base simulator could provide the answer. Alternatively, if the RNZAF proceeds with the C-130J purchase then either purchasing an advanced version of the RAAF C-130J SFT, or tapping into RAAF facilities could provide an economical solution.

Recommendations

With the experience levels of pilots reducing, and the costs of conducting overseas civilian

⁵⁰ J. Smith, HFTC.

⁵¹ Eight percent of the actual aircraft operating costs. Rolfe and Staples, p. 235.

⁵² Mac McClellan, March 1995, "Simulators are Best," *Flying* Vol. 122 (3), p. 7, 2/1c.

⁵³ A study concluded, "simulator maneuver motion may be of little potential training value." Paul Caro, July 1977, *Factors Influencing Simulator Training Effectiveness in the U.S. Air Force*, Alexandria, Virginia: Human Resources Organization.

⁵⁴ Steven Watkins, 11 December 1995, "C-130 Simulators Set," *Air Force Times* Vol. 56 (19), p. 34, 1/9p.

simulator training increasing, the RNZAF needs to consider the future of its C-130 simulator training. Four recommendations are presented which, if followed, will increase the simulator exposure of crews each year, significantly reduce the costs of conducting such training, or both.

1. The RNZAF should ascertain whether the RAAF C-130H simulator is available for use by RNZAF C-130 crews in the future. If so, the RNZAF should establish a training arrangement similar to that used before 1992.
2. The RNZAF should aim to increase funding of current C-130 simulator training to enable each pilot to conduct 20 hours of refresher training per year, commensurate with the requirements specified in the NZAP 700(S). A 20 percent increase to the current C-130 simulator budget would be required to achieve this.
3. The RNZAF should conduct a study to determine if other C-130 operators, such as the Swedish Air Force, are able to offer a more cost effective simulator-training package than the one current provided by HFTC. The study should also consider the ability to provide future SPS training.
4. Once a decision is made regarding replacement options for its current C-130 fleet, the RNZAF should ascertain the purchase and operating costs of a fixed-base C-130 simulator.

Final Thoughts

The aim of this paper is to highlight to the RNZAF the disturbing trend linking reducing budgets with decreasing flying hours, pilot experience, and simulator exposure. It demonstrated that RNZAF C-130 crews conduct less simulator training than their counterparts from other air forces. The paper also proposed several options and recommendations intended to increase the amount of simulator training conducted by RNZAF C-130 crews. The recommendations above are not intended as a total solution but more as a springboard from which to conduct further studies or to examine other possible avenues.

The most favoured solution is to recommence training with the RAAF. Enormous savings can be realized through this option but it is entirely dependent on whether the RAAF simulator is available for use again. If not, then the RNZAF must seriously consider increasing its current level of simulator funding. This will enable crews to receive at least the minimum of yearly

training specified by applicable RNZAF training policy, and in line with the level of training conducted by most other military C-130 operators.

Appendix A

Basic RNZAF Structure

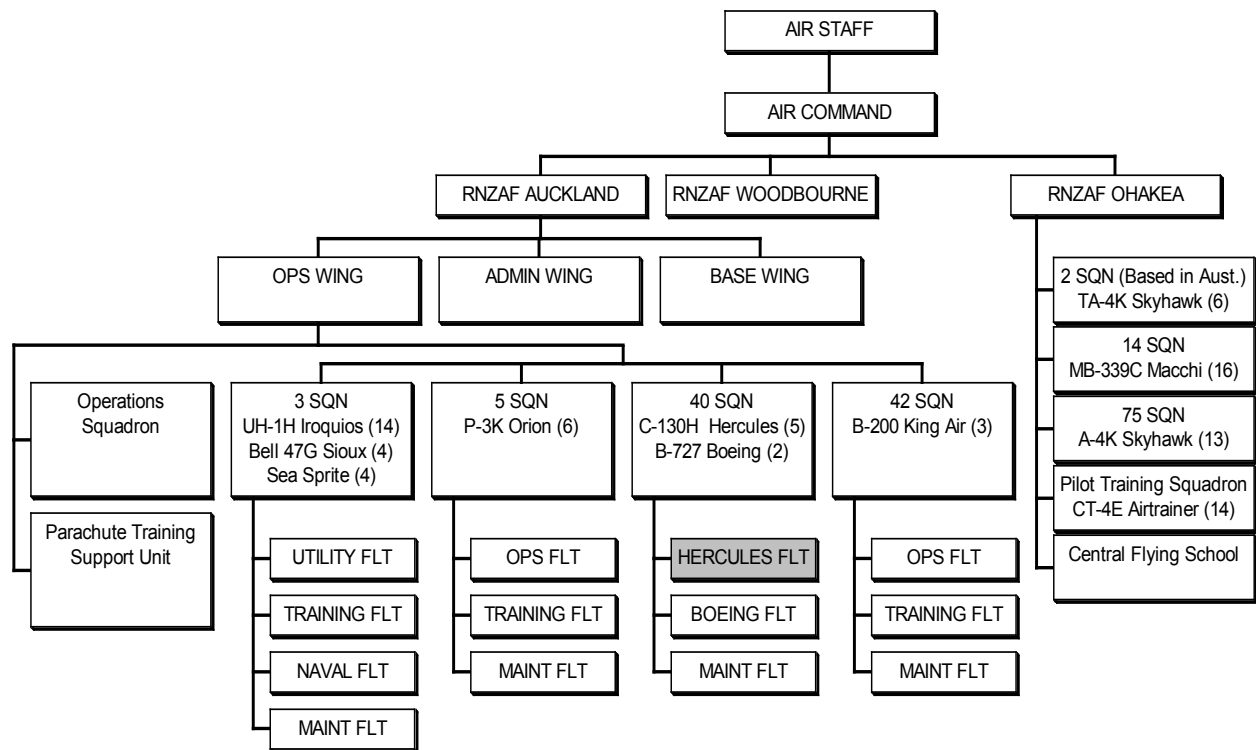


Figure 2. Basic RNZAF Structure⁵⁵

⁵⁵ Chart does not depict all RNZAF units. Air Command is the tasking authority for C-130 missions.

Appendix B

Frequency of Pilot Simulator Refresher Training

Table 5. Frequency of Pilot Simulator Refresher Training

Air Force	Number and Model of Aircraft Operated	Sessions/Year	Hours/Year	Facility Used
Argentina ⁵⁶	6 C-130B/H, L-100-30	2	32	HFTC
Belgium	11 C-130H	2	32	HFTC
Botswana ⁵⁷	3 C130B	1 ⁵⁸	12	HFTC
Canada ⁵⁹	27 C-130E/H/H-30	2	16	Own
Denmark ⁶⁰	3 C-130H	1	30	USAF
Israel	23 EC/KC/C-130E/H	2	32	HFTC
Kuwait ⁶¹	3 C-130E	2	40	HFTC
Norway	6 C-130H	2	? ⁶²	Reflectone
RAAF ⁶³	24 C-130E/H/J	2	24	Own

⁵⁶ J. Smith, current Manager SimuFlite Hercules Flight Training Center, 12 December 1999, Conversation with the author, Marietta, GA.

⁵⁷ Ezekiel Mosweu, Maj., Botswana Air Force, former C-130 pilot, 27 January 2000, *C130 Pilots*. [Internet, e-mail to the author]. *Available*: Available as e-mail from the author, t_davies@bellsouth.net.

⁵⁸ Frequency is sometimes reduced due to funding.

⁵⁹ Wade Hoddinott, Lt Col, CF, 24 January 2000, Former CO CC-130 OTU. [Maxwell LAN, e-mail to the author]. *Available*: Available as e-mail from the author, tony.davies@MAXWELL.af.mil.

⁶⁰ Michael Mouritsen, Maj., RDAF, 10 March 2000, *C130 Simulator Training*. [Maxwell LAN, e-mail to the author]. *Available*: Available as e-mail from the author, tony.davies@MAXWELL.af.mil.

⁶¹ Ali Hussein Ejbarah, Lt Col, KAF, C-130 Pilot, 28 January 2000, *C-130 Simulator Training*. [Maxwell LAN, e-mail to the author]. *Available*: Available as e-mail from the author, tony.davies@MAXWELL.af.mil.

⁶² This figure was not obtainable at time of writing. Geir Wiik, Lt Col, Norwegian Air Force, 14 March 2000, *C130 Simulator Training*. [Maxwell LAN, e-mail to the author]. *Available*: Available as e-mail from the author, tony.davies@MAXWELL.af.mil.

⁶³ Darren Webb, FLTLT, RNZAF, current exchange officer with 37 Sqn, RAAF Richmond, 10 November 1999, *Sim Staff*. [Internet, e-mail to the author]. *Available*: Available as e-mail from the author, t_davies@bellsouth.net.

RAF	25 C-130 Mk4/5 ⁶⁴	2	16	RAF
Netherlands ⁶⁵	2 C-130H-30	2	32	HFTC
RNZAF ⁶⁶	5 C-130H	1	16	HFTC
RNZAF ⁶⁷	6 P-3K Orions	1.3	21.3	RAAF
RNZAF ⁶⁸	2 Boeing 727-100QC	2	16	UA
Saudi Arabia ⁶⁹	48 C-130E/H, L-100-30	1	10	Own
Singapore ⁷⁰	10 KC/C-130B/E/H	2	16	Own
Sweden ⁷¹	8 C-130E/H1	2	32	Own

⁶⁴ RAF C-130 Mk4 and 5s are equivalent to C-130J and C130J-30s.

⁶⁵ Willem J van Es, LtKol, RNLAf, current FLTCDR RNLAf C-130, 6 December 1999, *Training RNLAf C-130 Simulator*. [Maxwell LAN, e-mail to the author]. *Available:* Available as e-mail from the author, tony.davies@MAXWELL.af.mil.

⁶⁶ Ian Davie-Martin, FLTLT, RNZAF, current 40 Sqn Training Officer, 3 November 1999, *RNZAF C-130 Simulator DCP Bids FY 99/00*, Facsimile to the author, Available from the author.

⁶⁷ Brett D. McKenzie, SQNLDR, RNZAF, current OFC 5 SQN, 13 January 2000, *No Subject*. [Internet, e-mail to the author]. *Available:* Available as e-mail from the author, t_davies@bellsouth.net.

⁶⁸ Ian, Davie-Martin, FLTLT, RNZAF, current 40 Sqn Training Officer, 3 November 1999, *RNZAF C-130 Simulator DCP Bids FY 99/00*, Facsimile to the author, Available from the author.

⁶⁹ Abdullah Al-Shelwi, Col., RSAF, C-130 Instructor, 10 November 1999, Conversation with the author, Maxwell AFB, AL.

⁷⁰ Tommy Tan, Maj., RSAF, 21 March 2000, *C-130 Sim Training*. [Maxwell LAN, e-mail to the author]. *Available:* Available as e-mail from the author, tony.davies@MAXWELL.af.mil.

⁷¹ Rickard Nyström, Maj., SwAF, 12 December 1999, *Jag Tikka*. [Internet, e-mail to the author]. *Available:* Available as e-mail from the author, t_davies@bellsouth.net.

UAE	6 C-130H	2	32	HFTC
USAF ⁷²	444 C-130E/H/J	1	18	USAF
USAFR/ANG ⁷³	See USAF	1	12	HFTC/USAF

⁷² United States Air Force, 1 November 1998, *Air Force Instruction 11-2C-130 Vol. 1: C-130 Aircrew Training*, Section A2.4.2, p 67.

⁷³ Ibid.

Glossary

AIRCMD	Air Command (RNZAF)
ALIS	Air Logistics Information Service
ATC	Air Traffic Control
ATSU	Auckland Technical Support Unit
AWACS	Airborne Warning and Control System
FY	Financial Year
CF	Canadian Forces
CRM	Cockpit Resource Management
CT	Continuation Training
CY	Calender Year
DCP	Defence Commitments Program
FGOFF	Flying Officer
FLTCDR	Flight Commander
FRA	Faculty Research Adviser
FY	Financial Year
HFC	Hercules Flight Commander
HFTC	Hercules Flight Training Center
HTO	Hercules Training Officer
KAF	Kuwait Air Force
MCT	Monthly Continuation Training
NZD	New Zealand Dollar
NZDF	New Zealand Defence Force
OFC	Operations Flight Commander
OUT	Operational Training Unit
QFI	Qualified Flying Instructor
QHI	Qualified Helicopter Instructor
RAAF	Royal Australian Air Force
RDAF	Royal Danish Air Force
RNZAF	Royal New Zealand Air Force
RSAF	Royal Saudi Air Force
RSAF	Republic of Singapore Air Force
SFT	System Familiarization Trainer
SPS	Self Protection System
SwAF	Swedish Air Force
TCPC	Technical Control & Planning
UA	United Airlines
USAF	United States Air Force
V _{MCA}	Minimum Air Control Speed

air logistics information service (ALIS). A computer database that tracks and logs engineering aspects relating to RNZAF aircraft. It includes take-off and landing data and flight hours.

avtur. Kerosene based fuel for aviation turbine engines.

C-130E. The third generation Hercules in production before 1966.

C-130H. The fourth generation Hercules in production prior from 1966 onwards. It features more powerful engines, updated avionics, and refinements to other aircraft systems. Subsequent versions, H1, H2, and H3 featured further electronic improvements.

C-130J. The fifth generation Hercules in delivery to the RAAF, RAF and USAF from 1999. While the airframe remained essentially the same, the rest of the aircraft systems were redesigned entirely. Its features include full glass cockpit and new propulsion systems.

circuit. The oval traffic pattern flown around an airfield.

conversion training. A course which all crewmembers must complete before taking up aircrew duties on any aircraft. For RNZAF C-130 pilots and flight engineers, this consists of a six-week ground school, twelve hours in a procedural trainer, 32 hours in a flight simulator, and eight flights in the aircraft.

continuation training. Regular refresher training conducted in the aircraft, simulator, or ideally both, where crewmembers practice flying exercises, emergencies or flying procedures.

flight commander. A flight commander in the RNZAF is the equivalent of a combined executive/operations officer in the U.S.

manday. An accounting term which means one working day for one person.

Bibliography

- Air Force Human Resources Laboratory. January 1981. *Aircrew Training Devices: Fidelity Features*. Westlake Village, California: Canyon Research Group, Inc.
- Air Force Human Resources Laboratory. January 1981. *Simulator Training Requirements and Effectiveness Study (STRESS): Executive Summary*. Westlake Village, California: Canyon Research Group, Inc.
- Al-Shelwi, A., Col., RSAF, C-130 Instructor. 10 November 1999. Conversation with the author, Maxwell AFB, AL.
- Assistant Auditor General (Operations). March 1999. *Flight Simulator Acquisition, Management, and Use*. Report of Audit Project 97064014. Washington, DC: Air Force Audit Agency.
- Aviation Safety Network Accident Database. [Internet, WWW]. ADDRESS: <http://aviation-safety.net/> [Accessed: 13 December 1999].
- Bing, Tony, SGT, RNZAF, ALIS user. 12 January 2000. *ALIS Data*. [Internet, e-mail to the author]. Available: Available as e-mail from the author, t_davies@bellsouth.net.
- Brausch, Ian, SQNLDR, RNZAF, current Operations Wing Executive Officer. 14 January 2000. *Sim Training Document: AKBR 4520/4 Paper on Simulator Training dated 22 January 1996*. [Internet, e-mail to the author]. Available: Available as e-mail from the author, t_davies@bellsouth.net.
- Caro, Paul W. July 1977. *Factors Influencing Simulator Training Effectiveness in the U.S. Air Force*. Alexandria, Virginia: Human Resources Organization.
- Cato, Robert, FGOFF, RNZAF. 12 March 2000. *Avtur Prices*. [Internet, e-mail to the author]. Available: Available as e-mail from the author, t_davies@bellsouth.net.
- Clayton, Alison. November 1998. "Simulation and Training: High Tech-Low Cost." *Jane's Defence Weekly* Vol. 30 (21), p. 25.
- Davie-Martin, Ian, FLTLT, RNZAF, current 40 Sqn Training Officer. 1 November 1999. *Sim Stuff*. [Internet, e-mail to the author]. Available: Available as e-mail from the author, t_davies@bellsouth.net.
- Davie-Martin, Ian, FLTLT, RNZAF, current 40 Sqn Training Officer. 3 November 1999. *RNZAF C-130 Simulator DCP Bids FY 99/00*. Facsimile to the author. Available from the author.
- Ejbarah, Ali Hussein, Lt Col, KAF, C-130 Pilot. 28 January 2000. *C-130 Simulator Training*. [Maxwell LAN, e-mail to the author]. Available: Available as e-mail from the author, tony.davies@MAXWELL.af.mil.

- Garrison, Paul. 1985. *Flying Without Wings: A Flight Simulation Manual*. Blue Ridge Summit, PA: TAB Books Inc.
- Graeter, Edwin A., Jr. May 1966. "The Simulator as a Tool in Obtaining Maximum Aircrew Efficiency." ACSC Research paper, Air University.
- Hoddinott, Wade, Lt Col, CF, former Commanding Officer CC-130 OTU. 24 January 2000. *CF C-130 Sim Training*. [Maxwell LAN, e-mail to the author]. *Available*: Available as e-mail from the author, tony.davies@MAXWELL.af.mil.
- Jackson P. ed. 1999. *Jane's: World Air Forces, Order of Battle and Inventories*. Surrey, UK: Jane's Information Group Ltd. Surrey.
- Jackson, Robert V., SQNLDR, RNZAF, currently Asst Dir Joint Ops for HQNZDF. 2 March 2000. *Info*. [Internet, e-mail to the author]. *Available*: Available as e-mail from the author, t_davies@bellsouth.net.
- MacPherson, Ian, SQNLDR, RNZAF, former Training Officer 3 SQN. 24 January 2000. *No Subject*. [Internet, e-mail to the author]. *Available*: Available as e-mail from the author, t_davies@bellsouth.net.
- Mayer, Benjamin George Jr., June 1981. *Determining the Training Effectiveness and Cost-Effectiveness of Visual Flight Simulators for Military Aircraft*. Monterey, California: Naval Postgraduate School.
- McClellan, Mac J. March 1995. "Simulators are Best." *Flying* Vol. 122 (3), p. 7, 2/1c.
- McKenzie, Brett D., SQNLDR, RNZAF, current OFC 5 SQN. 13 January 2000. *No Subject*. [Internet, e-mail to the author]. *Available*: Available as e-mail from the author, t_davies@bellsouth.net.
- Messerli, Robert E. April 1973. "Simulators for Pilot Training." AWC Research paper, Air University.
- Mosweu, Ezekiel, Maj., Botswana Air Force, former C-130 pilot. 27 January 2000. *C130 Pilots*. [Internet, e-mail to the author]. *Available*: Available as e-mail from the author, t_davies@bellsouth.net.
- Mouritsen, Michael, Maj., Royal Danish Air Force. 10 March 2000. *C130 Simulator Training*. [Maxwell LAN, e-mail to the author]. *Available*: Available as e-mail from the author, tony.davies@MAXWELL.af.mil.
- NATO Advisory Group for Aerospace Research and Development. Sep 1986. *Flight Simulation*. AGARD Conference Proceedings No. 408, AGARD.
- Nyström, Rickard B., Maj., SwAF. 12 December 1999. *Jag Tikka*. [Internet, e-mail to the author]. *Available*: Available as e-mail from the author, t_davies@bellsouth.net.

- NZAP 700(S), RNZAF Manual of Policy and Planning. 1995. Edition 2, Chap 2, Annex 3.
- Proctor, Paul. 29 November 1999. "Transport Sales Boom Hikes Training Demand." *Aviation Week and Space Technology*, pp. 48-49.
- RNZAF Air Command Operations. 25 January 2000. *DCP for C-130 Simulator Training Bids FY89-00*. Facsimile to the author. Available from the author.
- Rolfe, J.M. and K.J. Staples. ed. 1986. *Flight Simulation*. Cambridge: Cambridge University Press.
- Smith, J., current Manager SimuFlite Hercules Flight Training Center. 12 December 1999. Conversation with the author, Marietta, GA.
- Smith, Kevin L. July 1994. "Simulators: More Than an Emergency Trainer." *Marine Corps Gazette* Vol. 78 (7), pp. 31-33.
- Sweetman, Bill. August 1991. "Budget Battle for Military Trainers." *Interavia* Vol. 46, pp. 26-28.
- Tan, Tommy, Maj., RSAF. 21 March 2000. *C-130 Sim Training*. [Maxwell LAN, e-mail to the author]. *Available*: Available as e-mail from the author, tony.davies@MAXWELL.af.mil.
- Taverna, M. April 1993. "Managing Human Error." *Interavia* Vol. 48, pp. 23-24.
- United States Senate Committee on Armed Services. September 1984. *Development and Use of Training Simulators: Hearings before the Subcommittee on Tactical Warfare*. Washington, DC: U.S. Government Printing Office.
- United States Air Force. 1 November 1998. *Air Force Instruction 11-2C-130 Vol. 1: C-130 Aircrew Training*. Section A2.4.2, p 67.
- Van Es, Willem J., LtKol, RNLAf, current FLTCDR RNLAf C-130. 6 December 1999. *Training RNLAf C-130 Simulator*. [Maxwell LAN, e-mail to the author]. *Available*: Available as e-mail from the author, tony.davies@MAXWELL.af.mil.
- Waag, Wayne L. January 1981. *Training Effectiveness of Visual and Motion Simulation*. Williams AFB, Arizona: Air Force Human Resources Laboratory.
- Wake, David Gerald, Air New Zealand, B747-400 Second Officer. 13 January 2000. Telephone Conversation with the author.
- Walters, Brian. July 1994. "Flight Simulation: A Safe Way to Hone Skills." *Asian Defence Journal* Vol. 78, pp. 31-33.
- Watkins, Robert W. May 1980. "Military Flight Simulator Acquisition: What is the Goal?" ACSC Research paper, Air University.

Watkins, Steven. 11 December 1995. "C-130 Simulators Set." *Air Force Times* Vol. 56 (19), p. 34, 1/9p.

Webb, Darren, FLTLT, RNZAF, current exchange officer with 37 Sqn, RAAF Richmond. 10 November 1999. *Sim Stuff*. [Internet, e-mail to the author]. *Available*: Available as e-mail from the author, t_davies@bellsouth.net.

Wilk, Geir, Lt Col, Norwegian Air Force. 14 March 2000. *C130 Simulator Training*. [Maxwell LAN, e-mail to the author]. *Available*: Available as e-mail from the author, \tony.davies@MAXWELL.af.mil.