New Zealand Government

JOURNAL OF THE ROYAL NEW ZEALAND AIR FORCE

TE TAUAARANGI O AOTEAROA

VOLUME 6 – NUMBER 1 – 2020

A COLLECTION OF AIR POWER PAPERS, ESSAYS, ARTICLES, AND BOOK REVIEWS

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The Journal of the Royal New Zealand Air Force – otherwise known as the RNZAF Journal – is an official Royal New Zealand Air Force publication produced by the RNZAF Air Power Centre (APC). The RNZAF Journal is the professional journal of the Royal New Zealand Air Force, consisting of academically credible articles on air power, intending to serve as an academic forum for the presentation and stimulation of critical thinking, debate and education on air power.
The RNZAF Journal contains a broad collection of air power papers, essays, articles, and book reviews intended to promote and enhance air-mindedness, encourage professional mastery and stimulate debate and discussion about air power at all levels.

The submission of papers, essays, articles, and book reviews is open to anyone. Submissions must be relevant to the employment or sustainment of air power. Challenges to conventional thinking and accepted norms are encouraged, as are innovative recommendations or conclusions.

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The APC will formally call for papers, essays, articles, and book reviews for the Journal from February of each year. Submissions close August of the same year, however, submissions can be emailed at any time to: ohapc@nzdf.mil.nz.

Papers, essays and articles should not exceed 5000 words, and shorter submissions are encouraged. Submissions should be in Microsoft Word format using Chicago referencing with footnotes.

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Reviews of air power related books, either contemporary or historical, should consist of approximately 300 to 500 words.

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OPERATION MOA,
3 SQUADRON.

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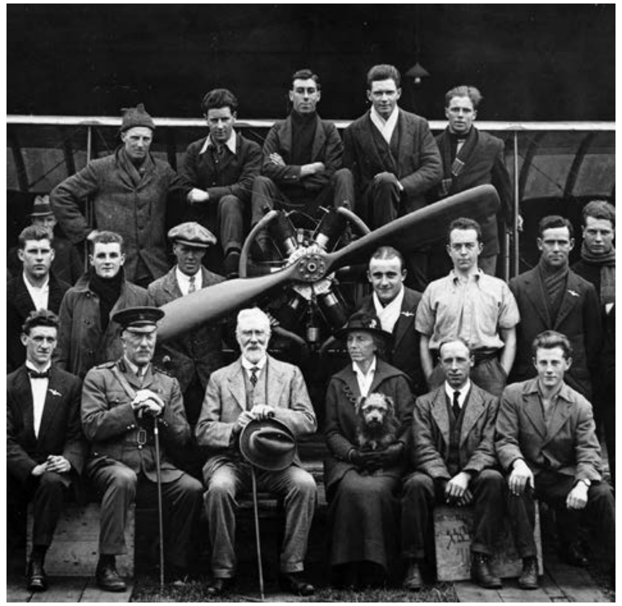

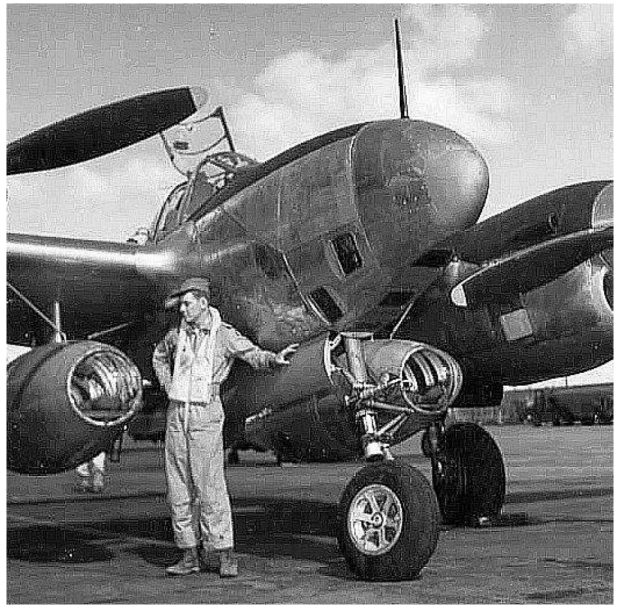

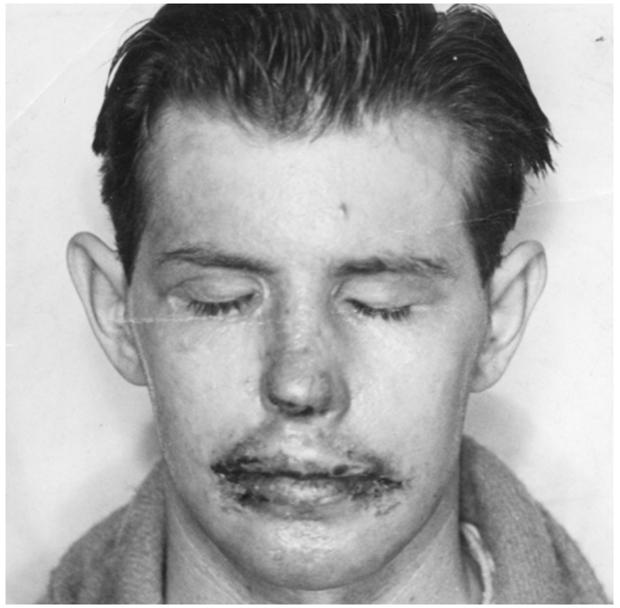

INTRODUCTION TO THE JOURNAL OF THE ROYAL NEW ZEALAND AIR FORCE

VOLUME 6 – NUMBER 1 – 2020

INTRODUCTION TO THE 2020 EDITION OF THE JOURNAL OF THE ROYAL NEW ZEALAND AIR FORCE

The Royal New Zealand Air Force Journal – in the fourth year in its modern iteration – is an adaptation and continuation of *The Journal of the Officers' School*, produced by the Royal New Zealand Air Force of 1959. At the time, it was designed to assist the professional development of officers' but it was short-lived. Today, the need for ongoing professional military education is vital for the development of all personnel, not just officers. All airmen require, at the very least, a working knowledge and understanding of air power to ensure the success of military air operations. Therefore, the RNZAF Journal was resurrected to create a platform for learning. Drawing from history and contemporary warfare, as well as peering into the future, to further our understanding of the application of air power.

CONCEPT OF THE JOURNAL OF THE ROYAL NEW ZEALAND AIR FORCE

The official title of the resurrected RNZAF Journal is *The Journal of the Royal New Zealand Air Force*, and it will continue in the spirit of the original journal by providing topical articles covering a range of air power related subjects. These will include, but are not limited to: RNZAF operations, air warfare, humanitarian assistance, technology, capabilities, training, strategy, theory, and security. Articles will be sought and drawn primarily from New Zealand Defence Force personnel, academics and interested civilians. Relevant reprints from companion journals and other relevant sources may be published from time to time.

The RNZAF Journal is intended to promote and enhance air-mindedness, encourage professional mastery and generate discussions about air power. The Journal serves as a forum for the presentation and stimulation of critical thinking, debate and education about air power. It is hoped, above all, that the articles are engaging and perhaps even draw the casual service reader into further personal study. Whether the reader is researching or simply seeking entertainment, we welcome you all equally.

The RNZAF Journal is designed as a means for anyone – no matter who they are – to present and/or digest ideas, views and analysis of air power matters through researched and reasoned papers, essays and articles. Material published in the RNZAF Journal may challenge current thinking, policy and conventions. The opinions and conclusions are exclusively those of the authors, and not necessarily those of the New Zealand Defence Force or the New Zealand Government.

EDITOR'S NOTE

BRIAN OLIVER | DEPUTY EDITOR RNZAF JOURNAL

The Air Power Centre is delighted to publish a diverse range of articles by an equally diverse range of people, while also acknowledging the efforts of contributors who were not published. This 2020 collection of air power papers, essays, articles, and book reviews contains a good balance of topics in a more-or-less chronological order, covering over 100 years of aviation progress, and also gives us a glimpse of the future. Starting with a reappraisal of Sir Henry Wigram's pioneering contribution to New Zealand aviation and, particularly, flight training, and finishing with an exploration of the potential for virtual reality to transform flight training in the future – closing the circle nicely – which no doubt Sir Henry's pioneering spirit would applaud. We feel sure there is something for every aviation enthusiast and we look forward to any feedback you may have, be it comments on articles or suggestions for future topics.

This edition opens with a reappraisal by Simon Moody about the contribution to New Zealand aviation made by the Canterbury Aviation Company. Initially set up by Sir Henry Wigram at Sockburn in 1917, the initial aim was to train pilots to meet the Aero Club of Great Britain Aviator Certificate standard prior to joining the Royal Flying Corp (RFC) or Royal Naval Air Service (RNAS). The problem was that by 1917 training in the UK had moved ahead significantly and holding the certificate gave little advantage – and together with the trials and tribulations of travelling to the UK by sea, as well as undergoing further training on arrival – only very few of the 186 graduates saw active service. While the author raises the question that ultimately the enterprise may have been a waste of effort, there is more to it than that, as the author points out. What Wigram did achieve was to put the fledgling aviation industry and the potential of military aviation on the New Zealand Government's agenda. By 1923 the New Zealand Permanent Air Force had been formed at the renamed Wigram airfield in honour of its founder. The author puts a strong case for the reaffirmation of Henry Wigram's role in developing New Zealand aviation, but perhaps not in the way that has become part of the legend.

The late 1960s and early 1970s was a time of great change for the Royal New Zealand Air Force, somewhat similar to today in terms of capability renewal. The current pandemic aside, the strategic situation was more complex, with the Vietnam War, the British withdrawal from Singapore and Malaysia, and the Cold War constantly threatening a hot war. The speech given by The Right Honourable David Thomson, Minister of Defence, on the 5th of November 1971 to the New Zealand Air Force Association (NZAFA), only days after the standing up of the Five Power Defence Arrangements, gives us an insight of the times. What is apparent is that some things do not change even after 50 years. The RNZAF had a genuinely high tempo to its operations, Asia generally was unstable and vulnerable, and China was in the throes of a Cultural Revolution, the outcome of which had still to play out. All this was occurring at a time when the government demanded restraint in expenditure of all government departments. The reader will surely note that in the intervening 50 years or so, while the world is very different, it is very much the same.

A subject close to any soldier's heart while deployed on operations is the availability of timely Aeromedical Evacuation, or AE. In our third article, Dr. Rob Visser gives us a snapshot of the history of AE and a glimpse into the state of the art in the RNZAF, in a very readable form of what is a highly specialised and complex medical discipline. Driven by the experience of myriad conflicts over the last 20 years or so, there have been many developments in both critical healthcare systems and aircraft systems that have brought unprecedented capabilities to the battlefield in the care of wounded soldiers, greatly improving survival and recovery. Many of these advances have carried over into the civilian world, and, as Rob points out, the skills and capabilities the RNZAF has in this area stand ready to support civilian AE in times of disaster at home.

Our fourth essay has, at its centre, a report conceived around 20 years ago titled the *Maritime Patrol Review*, which painted a dim picture of the state of maritime surveillance of New Zealand's exclusive economic zone, and especially so of airborne surveillance. The report recommended a ten-fold increase in aerial surveillance to meet the minimum requirements of interested government departments, such as Customs and Fisheries. This kind of increase was clearly beyond the capacity of the RNZAF's existing maritime patrol capability both logistically and financially, and it was also acknowledged that the RNZAF's P-3s were probably not the ideal platform for this kind of work. Consequently the report recommended that provision be made for a short- to medium-range maritime patrol aircraft to supplement the P-3, which could be operated by the RNZAF or a civilian organisation. This essay relates the subsequent chequered history of the project as competing priorities and changes of government raise and lower its profile, looks at where the project is currently, asks the question – is there still a need for such a capability and are there other options? – and perhaps serves to remind us that in all things defence, politics rules.

Our penultimate essay takes a look at the future of air power through the lens of artificial intelligence (AI). Written by the renowned Royal Australian Air Force (RAAF) air power strategist and author Professor Sanu Kainikara, it warns of the inevitability of AI intrusion into military machines, and cautions that the main obstacle will be humans, as they will be forced to make the cognitive leap of placing total trust into those machines to make life and death decisions – which may just be a leap too far for many societies. The author also raises the question of what a warfighting ethos will look like in a future dominated by autonomous machines. And what of *esprit de corps*, the intangible feeling that binds members of a military unit in the selfless performance of their duty? The character of war will be fundamentally changed, and perhaps machine war will be regarded as pointless if no one is put at risk. Professor Kainikara's essay lays a solid foundation for thought on the future of warfare as we stand on the verge of autonomous military machines.

Our final essay gives us a glimpse of the future in the context of how virtual reality (VR) has the potential to transform flight training and many other types of training across a multitude of disciplines. While still in a relatively early stage of development, some big players are exploring the possibilities, including the United States Air Force (USAF). The advantages are many and will potentially enable significant cost savings in both resources and time, and all in a repeatable and completely safe environment. The relative simplicity and transportability of a VR flight training system – compared to a full flight simulator – will allow students to hone their skills outside of hours under the tutelage of virtual instructors in a relaxed environment and at their own pace, thus enhancing and augmenting formal training. With technology moving forward unabated, the application of VR seems inevitable and will only be limited by the imagination. If it all sounds too good to be true, reading the essay will assist in informing your thoughts, and will help you consider the possibilities for its application in the RNZAF training environment.

To close the Journal we have two book reviews. They are historical in context and have some relation to New Zealand or the RNZAF. The first review by Louisa Hormann is of a book titled *The Guinea Pig Club*, and tells of the pioneering work of New Zealand plastic surgeon Sir Archibald McIndoe in treating Royal Air Force (RAF) and Allied aircrew that received severe burns on operations during World War II. *Many a Close Run Thing* is our second title and is reviewed by Squadron Leader (SQNLDR) Paul Stockley. *Many a Close Run Thing* is the personal recollections of Tom Enright, whose piloting career spanned the 1950s through to the 1980s, with both military and civilian airlines.

This issue of the RNZAF Journal spans the historical, contemporary, technical, and potential future of the RNZAF. It is hoped that readers find the articles interesting, informative and challenging. That is the point of the RNZAF Journal – it should make us think and reflect. By studying warfare, and in particular, air operations in support of warfare, we can increase our individual – and collective – understanding of our peers. The RNZAF Journal has a broad readership, not only within the NZDF, but also amongst those in the wider community who are interested in air and space power related topics. However, the journal is only as good as its contributions, and to ensure it holds its place as a valued publication, we encourage writers to put pen to paper, or fingers to keyboards as the case may be. So, is there a topic or perspective that interests you, and can you collate those ideas into an essay? If you can, then the APC would love to hear from you.

The majority of articles within this iteration of the Journal were written before the COVID-19 pandemic and its consequences, therefore, please keep in mind that some of the information within them may have been affected.

FLTLT ABEL (RIGHT) AND FLTLT THOMPSON (LEFT) OF THE RNZAF, IN THEIR OV-10 BRONCO. CHU LAI AIRFIELD, VIETNAM, 1971.

BEYOND THE LEGACY: RE-EVALUATING THE CANTERBURY AVIATION COMPANY, 1916–1918

SIMON MOODY | RESEARCH CURATOR
AIR FORCE MUSEUM OF NEW ZEALAND

AUTHOR BIO

Simon Moody was born in Dorset, England, and studied history, archaeology, and archive management at the Universities of Leicester, York and University College, London. He has previously worked with archives at the RAF Museum and National Army Museum in the UK and has written and lectured on their content. Moody is the co-author of *Under the Devil's Eye: Britain's Forgotten Army at Salonika*, published in 2004. He moved to New Zealand in 2009 to become Research Curator at the Air Force Museum of New Zealand in Wigram, Christchurch, and is responsible for overseeing the RNZAF archives and the research undertaken there.

INTRODUCTION

Air power history is littered with myths, legends and partially understood narratives. Some of these stories have permeated the historical fabric of their respective countries, becoming almost more resonant than the events they describe. The recently observed First World War Centenary was an opportunity – sometimes missed – to reflect on some of our established conversations and kōrero on the transformational events that occurred here in New Zealand and overseas, just over one hundred years ago.

One of these stories is that of the Canterbury Aviation Company. It goes something like this. In late 1916, the visionary and air-minded Christchurch businessman and politician, Henry Wigram, established a private company to train pilots on behalf of the New Zealand Government. It is created to provide pilots for the Royal Flying Corps (RFC) and Royal Naval Air Service (RNAS). Between 1917 and the 1918 Armistice, 186 young men were trained, a considerable achievement for a small country like New Zealand.

Taken at face value, it is an interesting but simple story. It is also a story that needs to be looked at more deeply to place it within the wider narrative of the war in the air. This paper is the initial result of overdue, new, and ongoing research and will look at several themes – ranging from the practical training undertaken, to the identity, demographics, and culture of the Company – to add some historical and social depth to the accepted tale, and perhaps reassess some of the stories along the way.

ORIGINS AND PURPOSE

Henry Wigram had long lobbied the New Zealand Government regarding the need for an aerial element to the armed forces. Inspired by a visit to Europe in 1908, where aerial record-breaking and achievements were occurring almost monthly and the Old World was very much enamoured by this new technological marvel, Wigram felt he saw the future. Addressing the New Zealand parliament in June 1909 the response was lukewarm apathy. As a newspaper owner, he used the press as his voice, producing a stream of articles in support of his argument. A further address to Parliament, in October 1909 perhaps predicted terrible air raids and devastation which came to pass some thirty years later at London and Singapore.[1]

Despite this extraordinary prediction, the New Zealand Government was not to be swayed and little was done other than sending a few officers to Britain for instruction in aviation. New Zealanders who wished to fight in the air during the coming war would have to travel to Britain or the Middle East to do so, as part of the fledgling Royal Flying Corps and Royal Naval Air Service.

1 Martyn, *A Passion for Flight*, Volume 3, 105-107; for a modern concise summary of Wigram's early interest in aviation.

The situation started to change with the outbreak of war. Private flying schools training pilots for the British, with tacit New Zealand Government approval, became a possibility. This was also fuelled by a rapid increase in both the size and scope of the RFC and air operations. In fact, the Canterbury Aviation company was not the first to appear in New Zealand. Leo and Vivian Walsh had set up the New Zealand Flying School at Kohimarama in late 1915, operating flying boats from the beach over the Waitemata Harbour.

Here we face our first assumption; that Wigram envisaged the Canterbury Aviation Company just as a way of training New Zealand pilots for the war. In fact, at a meeting in Christchurch in August of 1916, Wigram invited over 40 notables, including the Mayor, to discuss the possibility of forming an aviation enterprise in Canterbury. It was agreed that its purpose would be threefold:

1. To train aviators for the war.
2. To promote aviation for local defence purposes.
3. To encourage the science in its commercial aspects.

The Star newspaper reported the successful meeting, being provincially one-eyed in describing the initiative as "A Canterbury Enterprise." [2] But what these three points show was that Wigram's agenda went far beyond just training pilots. A suitable site near Sockburn called Carr's Farm was selected and cleared and plans made for the procurement of aircraft and equipment.

2 *The Star*, 23 August 1916, 3.

French Caudron training aircraft were ordered late in 1916 and Wigram achieved a great coup in convincing one of the leading instructors in England, Cecil Hill, to relocate with his family to Christchurch. All the pieces were falling into place.

By June of 1917 – following construction work, the delivery of the aircraft, arrival of Cecil Hill, and the resolution of some technical issues – the Company was finally ready to start training the first group of pilots in earnest. It was not a moment too soon, considering the heavy losses suffered by the Royal Flying Corps in France in the first half of 1917 and a widening scale and variety of aerial operations.

THE TRAINING

So, how did the School operate and what did the pupils learn? The system was described by one former pupil, Albert Parson, in an interview in 1967:

> *"For a pupil who wanted to learn flying...he had to pay a cash deposit of one hundred pounds...the company supplied a bed, mattress, dining room and kitchen equipment, and that was about all...At the end of the training, the government, acting on behalf of the RFC, paid our passage to England second-class, usually in a troop-ship. The government also refunded seventy five pounds on behalf of the Imperial Government, as part of our flying training fee."* [3]

3 Albert Parson, interview by Rodney Bryan, 1967. Ngā Taonga Sound & Vision.

Parson was a little harsh on the living conditions at Sockburn. In fact, considerable care and expense had been taken. In addition to three purpose-built hangars, the pupils occupied a twelve room accommodation block with a shared common room and kitchen. They also had meals cooked for a fee, and their rooms all had electric lights. These accommodation rooms still exist today at the Air Force Museum.

From the outset, the facilities at Sockburn had, to an outsider, a slightly more professional and business-like appearance than the rough-and-ready tented existence at Kohimarama. But the objective was the same – to make sure each pupil could pass the examination on rudimentary flying required by the Royal Aero Club to acquire an aviator's certificate or 'ticket' as it was nicknamed. Each course consisted of five to six pupils, and they would usually be tested together in small groups, dependent on progress.

THE CORPORATE IMAGE – FORMAL GROUP OF PUPILS AND STAFF AT SOCKBURN, INCLUDING HENRY WIGRAM AND HIS WIFE AGNES, EARLY 1918. 2017/110.32

CHIEF INSTRUCTOR CECIL HILL TEACHING CANTERBURY (NZ) AVIATION COMPANY TRAINEES ALFRESCO, SOCKBURN, C. 1917. 2014/076.360.

So what was required to pass in the presence of Major Sleeman from Wellington? Sleeman represented the New Zealand Government and ensured all was done correctly and above board during the tests. Pupil Ross Brodie helpfully recorded it in his diary:

> *"The airman must ascend by himself and do five figures of eight and then land within 60 yards of a given mark in the centre of the drome; this has to be repeated a second time and on going up a third time the pupil has to ascend to not less than 350 feet and then shut off the engine and land on the 'drome without putting the engine on again."*

By 1917, this was pretty basic stuff and a test largely unchanged since the origins of the Aero Club in the 1910s. It was what Wigram would have witnessed on his European visit in 1908, and envisaged working in New Zealand. The level of training was what Cecil Hill had been training pupils to do in England on a bigger scale before his employment by the Company. They would then go on to train further with the RFC and RNAS, as Parson told us earlier.

Occasionally, the demonstration of military aviation also took on an almost comically amateurish tone. Neville Harston from Hawke's Bay trained with the Canterbury Aviation Company and took his 'ticket' with several other pupils on the 24 August 1918, watched by military observers, press reporters, and Sir Henry Wigram himself. He then did something a little different, as the watching press observed:

> *"There was a very interesting incident when Harston took up a number of potatoes for bomb dropping practice. Flying at an altitude of 600 feet, while doing his 'figure of eights' his first shot fell just three yards wide of the mark, and a second shot just missed the chairman of the company (Mr H. F. Wigram) who was standing close to the mark. The potato whizzed down within a foot of Mr Wigram's head, and he laughingly secured it as a trophy of the occasion. Harston's shooting was conceded to be extraordinarily good especially in view of the fact that, he was turning at the time, and his feat gave promise of success with the 'real thing'."* [4]

There were significant problems with this training. First, it was out of date by late 1917. Robert Smith-Barry and others were refining and improving training methods in the RFC in Britain to produce more competent pilots and reduce the appalling accident rate. Increasingly, Aero Club tickets were overlooked in favour of complete courses of training in dedicated RFC and RNAS units; in short, the age of the private flying school was being superseded by completely in-house and military controlled training.

An even greater problem was the length of time it took to get a pupil to the stage of ticketing at Sockburn. John Lochhead of North Canterbury commenced his training on 12 September 1917 with a 10-minute trial flight. This rare record, kept by instructor Cecil Hill and handed to Jack on his departure for England, details his instruction. By the time he had been ticketed on the 13 October, he had 5 hours 45 minutes flying time, only 2 hours 45 minutes of which were solo. The test accounted for the 45 minutes.[5] These hours were pretty typical.

In stark contrast, with plentiful men and materiel, the RFC and RNAS were churning out more experienced pilots with considerable speed, fuelled by the terrible losses during 'Bloody April' at Arra in 1917. While it might have taken one or two months to get a pupil of Sockburn to the rudimentary stage of training required by the Royal Aero Club, by late 1917, in Britain, the pace was intense. Leonard Isitt commenced his flying training at No. 66 Training Squadron on 13 May 1917.[6] He graduated from the Central Flying School on the 26 June 1917 with 31 hours, of which 11 were solo. He arrived in France in early August with 51 hours 30 minutes, after further training. Even allowing for cutting corners due to those recent losses, this indicates that the RFC system could churn out an operationally functional pilot in just four months, as opposed to one to two months to learn only the most basic skills at Sockburn.

Unlike at Kohimarama – where a lot of ground instruction was undertaken, like wireless, map reading and navigation – the Canterbury Aviation Company,

4 *The Lyttleton Times*, 25 March, 1918, 5.

5 Lochhead, *Record of Training at Sockburn*, 1917.

6 Future Chief of Air Staff for the RNZAF and Cantabrian, Sir Leonard Isit. His father (of the same name) invested in the Canterbury Aviation Company.

having started later, deliberately attempted to restrict its training to piloting. Wigram's propaganda machine gave the reason for this in the prospectus to commemorate 'The First One Hundred Pilots' trained at Sockburn. Published in June 1918, it stated:

> *"...all these subjects form part of the course that the pupils will have to undergo after their arrival in England... if they have some knowledge of the construction of the engines and planes they use, and of the elements of drill, so much the better, but their departure ought not to be delayed for instruction in other subjects, which in any case they will have to take up at Home."*[7]

And study they did, on arrival in England, in a system now much more scientific and advanced than anything Cecil Hill had experienced and that could take many months to complete by 1918. But Wigram's assertion that he did not provide this training is rather misleading. Arnold McDonald recorded the following activities in his diary on the 5 May 1918, indicating that some other military instruction, other than drill, occurred before departure:

> *"Drill again this afternoon. And we have a hot Staff S. Major and he puts in the ginger. Lecture on the esprit de corps of the RFC."*[8]

Another aspect of the School that contributed to the lack of speed of training was the risk and lack of resources. No pilot was killed during its wartime operations. How is this explained, given that sixteen New Zealanders died in Britain in training accidents as either pupils or instructors in the School's wartime operational period? The simple fact was that at Sockburn – and also at Kohimarama – the approach to training was expediently conservative and cautious. Both schools had a single instructor,[9] a handful of aircraft, and a not-plentiful supply of replacement engines or spares. Serious accidents were to be avoided. The loss of the irreplaceable instructor was a particular risk. The cumulative effect of all these factors, and the long journey to Britain, affected the chances of Sockburn pupils seeing any military action.

To demonstrate, let us return to John Lochhead. Having been ticketed on the 13 October 1917, he left New Zealand a month later, and spent a further month at sea before arriving in England. It was then that the intensive training really began. First, at the RFC Cadet Wing at Hastings, then at the No. 2 School of Aeronautics at Oxford University. Due to illness, it wasn't until 11 months after he had first flown at Sockburn, in August of 1918, that he recommenced flying training. Ironically, he ended up learning to fly seaplanes and had still not become operational when, on the 11th November 1918, he recorded in his diary:

> *"On general parade...it was announced that the Armistice had been signed. Nearly everyone in the camp was stunned."*[10]

And so he would have been. Like most of the pupils of the Canterbury Aviation School, he had failed to make his intended mark in the Great War in the air despite spending over a year either in training or transit.

7 Wigram, *The First One Hundred Pilots*, 1918.
8 McDonald. Diary, 1918.

9 Although Sockburn used mechanic and early qualifier Bert Mercer as 'back-up', he was too old to proceed to Europe.
10 Lochhead. Diary, 1917.

SECOND LIEUTENANT ARNOLD MCDONALD IN RAF UNIFORM, LATE 1918. MCDONALD'S DIARY OF HIS TIME AT SOCKBURN IS A VITAL SOURCE ON THE CULTURE AND PROCEDURES AT THE AERODROME IN 1918. 2017/110.30

PUBLIC PROFILE

It was decided relatively early on that the work of the Company would be promoted to the public. At all times, Wigram mobilised his media interests to promote the works at the aerodrome. *The Lyttelton Times* and other newspapers reported on the progress and successful qualification of pupils. Wigram also published a highly promotional publicity brochure entitled *The First One Hundred Pilots* in June of 1918.

In terms of visual publicity, the Walsh brothers commissioned a film about their work, which the Sockburn pupils viewed at the cinema on its release in May of 1918. Wigram chose to hold an open day, selling tickets to the event to raise revenue for the Company at the same time. The first effort saw the weather too squally, but on 5 September 1917, only days after the first pupils qualified, the tiny airfield was packed to the boundary. The women's pages of *The Star* newspaper described the event vividly:

> *"The day was perfect and the huge crowd was surely representative of the citizens of Christchurch – everyone seemed to be there. Some of the most enthusiastic and appreciative spectators were the schoolboys, who seemed to be having the most glorious moments of their lives. One boy remarked 'It was a hummer'. In schoolboy vocabulary what greater expression of delight could be used?"*[11]

11 *The Star*, 6 September 1917, 7.

HAVING SOME FUN. CANTERBURY (NZ) AVIATION COMPANY STAFF AND STUDENTS WITH A CAR.

LEFT TO RIGHT: C.J. MCFADDEN (PUPIL) IN FRONT OF VEHICLE. J.G MACKIE (MECHANIC) BENDING OVER. CECIL MACKENZIE HILL (INSTRUCTOR) UNDER VEHICLE. J.F. LOCHHEAD (PUPIL) HOLDING JUG. J.C. MERCER (PILOT) RIGHT SEAT. H.G.A. MORSE (PUPIL) LEFT SEAT. G.A. NICHOLLS (PUPIL) RIGHT SEAT. R.A. GRANT (PUPIL) LEFT SEAT. CAUDRON BIPLANE IN THE BACKGROUND. 2014/076. 383

Pupil, Ross Brodie, was more measured in his assessment of the day:

> *"It was reckoned that between four to five thousand people assembled to see Mr Hill give a wonderful exhibition of flying. His greatest feat was to loop the loop – it was done at a height of almost 200 feet – this was the first time this feat had been done in New Zealand."* [12]

12 Brodie. Diary, 1917.

Ironically, the great Cecil Hill would die performing the same manoeuvre at Sockburn in 1919, a loss from which the Company struggled to recover.

In addition to open days and demonstrations, Henry Wigram was always looking for ways to promote the Company's image, and perhaps make a bit of money to boot. One of the more interesting initiatives was the *Song of the Pakeha Flying School*, sold through the auspices of *The Lyttelton Times* newspaper. Wigram wrote the lyrics, and Mildred Farquar-Young penned the music. The lyrics were nothing patriotic, but curiously, an odd smorgasbord of Pakeha, Māori, and zoological themes. The first verse demonstrated only a rudimentary knowledge of both Te Reo and indigenous fauna, going like this:

> *"We are Pakeha boys of the Kahu tribe,*
> *who dwell on a fertile plain.*
> *Where the moa once trod on the tussock sod,*
> *but never will tread there again.*
> *The moa stood high as a tall giraffe,*
> *and rattled his gizzard stones.*
> *But since he omitted to learn to fly,*
> *there only remain his bones."* [13]

The chorus continued, more jingoistically:

> *"The red, white, and blue has a meaning new,*
> *the Army, the Navy, the Air.*
> *The thin red line, and the white ensign,*
> *and the blue overhead, so fair."* [14]

13 Music and Lyrics, *Song of the Pakeha Flying School*.
14 Ibid.

The second verse was in a similar vein. Sadly, we do not know if the song was ever actually sung by the pupils or if it was simply a bit of commercial publicity or jingoistic ephemera. It is certainly not mentioned in any surviving personal writings by them.

THEMES OF CULTURE AND SOCIAL IDENTITY

An important question now arises. Who were these young men who trained at Sockburn? More contextual research on their backgrounds is ongoing, but a basic geographical breakdown of the celebrated 'First One Hundred Pilots' provides an interesting set of results. According to this chart, the bulk (some 40%) came from what we now would describe as greater Christchurch. However, the modern suburbs were still largely rural and farmed. With another 18% from rural Canterbury, a dominant demographic emerges. Young men like Ross Brodie of Rangitata, James Royds of Riccarton, and Jack Lochhead of Omihi were typical of the well-educated sons of local farmers and landowners. They could certainly afford the £100 fee charged for the training. As far as the pupils from elsewhere were concerned, a predictable tailing off occurs the further north one goes. This is probably the result of a preference for the nearer New Zealand Flying School at Kohimarama but also indicates the schools were not necessarily in direct competition. Indeed, there was considerable communication and some collaboration between them in their common purpose.

Another defining factor is the contemporary passion amongst the pupils for new technology. Almost all the surviving personal sources place a good deal of emphasis on this. Tinkering with motorcycles, cars, and of course, learning to look after the aircraft engines themselves – which, in itself, was important – as the Company had little in the way of mechanical support. A lot of time was spent in the hangars tinkering with the engines. Perhaps representative of a contrasting sort of technocratic pupil to the wealthy Canterbury farmer's sons was motor mechanic Ernest Taniwha Sutherland of Ngāti Apa and Ngā Wairiki, the first Māori pilot to qualify in New Zealand.

Edwin Wilding, another early pupil and the first to qualify, was also one of those early 'petrol heads' and used the phrase "messing about" at Sockburn a lot in his diary. For some of the pupils, it thus became home away from home. This was partially because pupils from Christchurch often also stayed in the accommodation there for early morning flying. This was due to the tendency of the wind to increase in the afternoons and potentially disrupt training.

There seems to have been a youthful sense of fun. Tennis courts were built and much socialising took place at the accommodation block in the evenings. It must have been a very youthful masculine environment, perhaps tempered by Cecil Hill's older age and experience (he was in his thirties). The youth of the pilots also led to some breakdowns in both behaviour and discipline. And it was not just the trainees. Wigram's diary records a chance visit by the Company secretary Charles Hervey on 18 August 1917:

> *"Hervey reports that the cook was drunk last week for two days. Mrs Hill assisted in the cooking, also that the gate of the paddock has been continuously left open, also that the pupils took up floor-cloth(s) for dance and tore it in relaying, that crockery had been left about unwashed and some broken, petrol cases also left about the grounds. That pupils have been rowdy with a lack of discipline. Told Hervey to speak to Hill and report to me."* [15]

It seems the exuberance of youth continued into 1918. Arnold McDonald records night-time 'raiding' of other pupils in their rooms with a team, including Hori Morse, appropriate to their frequently private boarding school education.[16] Occasionally, things got out of hand. McDonald reported another dangerous and potentially expensive incident with Morse in the common room on 12 May 1918:

> *"Morse fired a chair at my head and got a bull, also an electric globe* [light fitting]. *I hope he does not go off his rocker."* [17]

Their military status as cadets in training and being under military orders can also be reinforced along with a fervent patriotism and commitment to the establishment by their actions. When Christchurch erupted in rioting [18] following the attempted conscription of married men in the city on 29 April 1918, Arnold McDonald recorded the pupil's reaction at meeting two of their number, who:

> *"...informed us that a riot was in progress at the Drill Hall. We go down in Chubby's car and gradually collect school chaps on the way down. We see a lot of disgraceful behaviour but don't manage to get into a fight. We escort a returned soldier through the crowd."* [19]

In terms of less anti-social interactions, dances were held at the school, always with a chaperone in attendance. They were usually held to farewell groups of pupils to Europe and were reported in Wigram's newspaper, *The Lyttelton Times*. Local pupils of standing also held social events. Edwin Wilding was the first pilot to qualify on 24 August 1917 and was a member of one of the first families in Christchurch. He and others threw dances and parties to which his fellow pupils were invited, such as the one recorded in his diary, dated the 28 September 1917:

> *"Dance a great success – about 19 couples. Had a jolly good time. All the flying boys turned up but wouldn't dance. I think they were quite happy smoking and playing billiards."* [20]

This brief reference is interesting as it shows there was a clear sense of collective identity among these young men. In more modern terms, perhaps they might even be described as the mechanical equivalent of 'geeks' or 'nerds' given their collective interests, rather than conforming to the social norm.

15 Wigram. Diary, 1917.
16 McDonald. Diary, 1918.
17 Ibid. In fact, Hori George Morse proved to be consistently unstable, having crashed earlier in his training and only just managing to be accepted to complete the training due to his poor progress. He later served with the 'Black and Tans' during the bitter Irish War of Independence (1919-1921). He was convicted of murder in 1924 in Australia, shooting his common-law partner dead with a revolver on board a ship as she attempted to leave him.
18 In Christchurch on 29 April 1918 – in response to the conscription ballot of married men (known as the Second Division) – a group of over 5,000 (mainly women) disrupted the call up, fought with the police, and even stormed the King Edward Barracks. Stevan Eldred-Grigg, *The Great Wrong War* (Auckland: Penguin Random House, 2014); contains more information on this event.
19 McDonald. Diary, 1918.
20 Wilding. Diary, 1917.

THE HEROIC AIRMAN ENCAPSULATED. HALF-LENGTH PORTRAIT OF E.J. ORR IN FLYING CLOTHING STANDING IN FRONT OF A CAUDRON – G.III FACING LEFT.

THIS PORTRAIT WAS HIS ROYAL AERO CLUB CERTIFICATE PORTRAIT. ORR, FROM PUKETAPU, HAWKE'S BAY, QUALIFIED AT SOCKBURN ON 24 AUGUST 1917, AS CANTERBURY AVIATION COMPANY GRADUATE NO 6. 1984/171.5

ENAMEL BADGE WORN BY GRADUATES OF THE CANTERBURY AVIATION COMPANY. THIS ONE BELONGED TO NEVILLE HARSTON OF NAPIER. 1987/398.37

The contemporary self-image of the young pilots under training was also very important. This was very much the age of the heroic aviator, and pre-war pioneers and feats were still strong in memory. The pupils certainly found this idea attractive and the Company obliged. As was already fashionable in Europe, for their ticket photos, the pupils posed heroically in front of their Caudron aircraft, adorned in fine sets of leather coats, helmets, and gauntlets, which they rarely wore under training. In fact, most wore a motley assortment of balaclava, and thick jumpers for protection during training. These staged photographs achieved their aim – newly qualified heroic aviators had to look the part.

Enroute to Britain, the graduates also had to be identified as more than just civilians on board the troopships, in lieu of the issue of proper RFC, RNAS, or RAF military uniform upon arrival. Special brevet badges were issued for purchase by both schools to distinguish them. There was even discussion of a special interim uniform later in the war for the Sockburn pupils to wear while under training and in transit.

It wasn't just young men who made their way in this strange, new business enterprise either. In September 1918, eighteen-year-old Kura Asquith was hired to assist the secretary C.W. Hervey in clerical duties.[21] While she almost certainly spent much of her time in the Company offices in Cathedral Square, a recently discovered photograph of her in flying clothing shows that she was also able to experience first-hand this rare, new, and exciting form of transport as a perk of her job.

21 *The Canterbury Aviation Company Cash Book*, 1916-1923.

SACRIFICE

Despite the zero-fatality rate in training at Sockburn during training, the circumstances of the Great War did claim a share. Daniel Spence of Christchurch contracted influenza and died in July 1918 en route to England. He was buried at sea.[22]

Of the few who got to the war, two others also perished. On the eleventh day of the eleventh month of 1918, Allan Macdonald was instructing at Stamford in Lincolnshire when his Avro crashed and he was killed. Two days earlier, James Sloss of Cheviot was wounded carrying out a bombing raid in Belgium. Complications set in and he died on 23 November 1918.[23]

BEYOND THE LEGACY

In the greater scheme of the Great War, the impact of the Canterbury Aviation Company's activities at Sockburn between 1917 and 1918 was limited. Kohimarama, founded back in 1915, could boast some of the most well-known aviators from New Zealand, men like Keith Caldwell, Mac MacGregor, Ronald Bannerman, and several more. Fewer of the Canterbury Aviation Company pupils saw action. It was simply set up too late to fulfil its cited purpose in training pilots for the war.

Does this mean, in historical hindsight, that the role of the Canterbury Aviation School was a wasted effort? The answer is, of course, more complex than this

22 Martyn, *For Your Tomorrow*, Volume 1, 50.
23 Ibid.

one simple question. While it failed in its first aim of rapidly supplying pilots to aid the British war effort, the significance of the Canterbury Aviation Company was that – unlike Kohimarama – these aviation activities left a physical footprint, in keeping with the wider second and third aims agreed in 1916. Wigram's vision had produced a small but fully functional airfield in a good location. It was capable of expansion and had use as a civil facility in the interwar years for commercial aviation. This established infrastructure clearly had the potential to become the future home of the fledgling Royal New Zealand Air Force. Whether this was Wigram's original intention in setting up the Company, harking back to his pre-war badgering of the New Zealand military, we shall perhaps never know.

The bleak and austere New Zealand economy post-war ensured there was no golden future for the Canterbury Aviation Company.[24] Hard times and no need for military pilots ensured the ruin of its finances, despite efforts to diversify into passenger flights, joyrides and demonstrations, as well as early attempts at mail delivery.

The end result was the purchase of the assets of the struggling Company by the New Zealand Government, financially supported by Wigram in 1923. At the same time, the establishment of the New Zealand Permanent Air Force at Sockburn came about through a post-war reassessment of New Zealand's needs, the recent experience of New Zealand airmen, and the crucial role of the Royal Air Force in securing final victory in the First World War. Whether by design or circumstance, Henry Wigram had, at last, achieved his aim of creating a fledgling military aviation wing of the New Zealand military, and what later became our Air Force was born. Although the Canterbury Aviation Company became history (and ultimately legend), its fascinating legacy is now at last starting to be unraveled and told from social, military, and commercial perspectives, and in more clarity and detail. In itself, this is a positive outcome from the First World War Centenary Commemorations.

Special acknowledgement should be given to Errol W. Martyn and Dr Adam Claasen for their assistance and useful discussion in the preparation of this article.

24 See also *RNZAF Journal 2019*, Simon Moody, *Reflecting on the Bettington Report of 1919 - A Centennial Legacy*, 55-63; for a discussion of the advisory visit by Col A.V. Bettington RAF in 1919 and the difficulties of post-war austerity in New Zealand.

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14 SQUADRON,
TENGAH, SINGAPORE, 1956.

THE ROYAL NEW ZEALAND AIR FORCE IN THE 1970S

THE RIGHT HONORABLE DAVID THOMSON | MINISTER OF DEFENCE

The following text under the title 'The Royal New Zealand Air Force in the 1970s', was a speech given by the then Minister of Defence, The Right Honourable David Thomson, to the New Zealand Air Force Association on the 5th November 1971.

INTRODUCTION

The Right Honourable David Thomson was a National Party MP representing Stratford, Taranaki and Minister of Defence in the Holyoake government from December 12th, 1966 to February 9th, 1972. He served with the Army in the Middle East during World War II and was awarded the Military Cross in 1942. At the time this speech was delivered in November of 1971, the National Party – after four successive terms – had become increasingly unpopular as the economy took a downturn with the collapse of wool prices and the depressed dairy and meat markets. Abroad, the unpopular Vietnam War was on-going, the US tentatively courted Mao Zedong amid an acrimonious split in Sino-Soviet relations, and Britain had recently withdrawn its forces from Malaysia and Singapore to 'East of Suez' – marking the end of an era for Britain, and its final demise as a global power. Perhaps because of the prevailing strategic situation in Asia, and despite a challenging economic climate, the Royal New Zealand Air Force (RNZAF) had transformed in years previous with modern US aircraft types. This was largely due to the extraordinary efforts of Air Vice Marshal, Ian Morrison, who was Chief of Air Staff from November 1962 to July 1966. The uncertainty of the times, strategically and economically, is similar to today in some respects and gives a fascinating insight into the ebb and flow of political and economic events.

THE ROYAL NEW ZEALAND AIR FORCE IN THE 1970S

New Zealand is entering a new chapter in its relationship with its Asian and Pacific neighbours. We are now required to think of defence primarily in terms of our known national role. Only five days ago, on the 1st of November, the new Five Power Defence Arrangements in Malaysia and Singapore came into being. The Commonwealth Strategic Reserve, with which we have been associated since 1955, has been disbanded. The considerable British military presence, within which our role was expressed in the past, has been greatly reduced. In future, the British presence will be commensurate with that of Australia and New Zealand. In the New Five Power Arrangement, New Zealand will be an equal partner.

This is a completely new concept. It represents a fundamental change in the framework of our operations in South East Asia. For the first time, we will be making a contribution to the security of our Asian neighbours without a large-scale great power presence.

The contribution of Britain, Australia and New Zealand to the joint ANZUK force in Malaysia and Singapore will be of similar nature. New Zealand is providing one 3-company Infantry Battalion, one naval frigate on station, and one squadron of transport aircraft supplemented by the periodic deployment of strike aircraft. To coincide with the coming into force of the new arrangements, the RNZAF's Skyhawks are currently making their first deployment to Malaysia and Singapore.

It is gratifying that our long-standing cooperation with Britain in this area is to continue, as will the traditional association between the three services of our two nations, including the RNZAF and the Royal Air Force (RAF). There is no need for me to remind you that our association with the RAF has given us an unrivalled opportunity to develop our own professional standards and our own *esprit de corps* in the RNZAF.

Although the RNZAF is the youngest of the three services, it has developed as a flexible and indispensable arm of the New Zealand Armed Forces with substantial responsibilities in the protection of New Zealand's interests at home and abroad.

The 30 years leading up to the establishment of the RNZAF as a separate service in 1937 were years of struggle. As early as 1909, the father of New Zealand aviation Sir Henry Wigram, was urging in the Legislative Council for the formation of a flying corps as part of the country's defence forces. The stimulus of the First World War saw the establishment of the first flying schools at Sockburn and Kohimarama, but the War ended without any form of military air organisation.

In the face of public apathy and official indifference, a small band of enthusiasts kept alive the torch of air power and in 1923, the New Zealand Permanent Air Force was established as part of the military forces controlled by the Army. By 1928 the RNZAF consisted of five officers and 17 other ranks, with two airfields at Hobsonville and Wigram. In 1930, what could be termed the Air Force's first active operations were carried out when a DH60 Moth seaplane was sent on board *HMS Dunedin* to Western Samoa. The depression years naturally affected the development of the Air Force, but by the end of 1936, the international situation forced the Government to give serious consideration to plans for expansion. Wing Commander Ralph Cochrane was borrowed from the RAF to report on the requirement for an adequate air defence scheme and became New Zealand's first Chief of Air Staff with the passing of the Air Force Act in 1937. Under his direction, the foundations of a first-class fighting force were laid.

During the Second World War, more than 50,000 New Zealanders joined the RNZAF, of whom over 10,000 were transferred and served with the Royal Air Force. During the early war years, the primary task of the RNZAF was to train aircrew for the RAF. With the entry of Japan into the War, operational squadrons were formed for home defence, and later, for operations in the Pacific campaign. In the European theatre, New Zealand squadrons in the RAF totalled seven. Long before their formation, New Zealand aircrew were serving in the bomber and fighter units that played a heroic part in the early days of the War. It is said that one pilot in every 12 in the Battle of Britain was a New Zealander. The end of the War saw the RNZAF reorganised on a peace-time basis.

The service had emerged from the conflict with wide experience and a fine reputation on which to build the future. Since then, RNZAF squadrons have served widely in Japan with the Commonwealth occupation forces, in Cyprus, in South East Asia, and the South Pacific. Their role has been wide-ranging. 17 Squadron served in Malaya as part of the Commonwealth Strategic Reserve in operations against communist

RT HON DAVID THOMSON, MINISTER OF DEFENCE AND MINISTER ASSISTANT TO THE PRIME MINISTER, PERFORMING A CIVIC DUTY, 15 AUGUST 1968. PHOTOGRAPH BY REVELLE JACKSON, FROM THE UPPER HUTT HERITAGE COLLECTION.

P-3 ORION AND WEAPONS DISPLAY.

terrorists during the Emergency. 75 Squadron served in Malaya in the same context and also during the Indonesian confrontation. 41 Squadron has flown its Bristol Freighters all over South East Asia carrying out a variety of tasks, from supply dropping over the Malaysian jungles to delivering supplies to New Zealand troops in Vietnam. No. 5 Maritime Squadron based at Lauthala Bay in Fiji until the change to Orions combined its military role with the provision of medical aid and rescue missions to the outlying islands.

In these ways, the RNZAF has supplemented the many other operations of the New Zealand Government

and the activities of many individual New Zealanders in making a contribution to the security and stability of the area of our principal strategic concern. The Air Force has contributed to the development of New Zealand's relations with its Asian and Pacific neighbours not only through the forging of links with allied air forces in the area. Through participation in SEATO (South East Asia Treaty Organisation 1954 - 1977) exercises and training with the air forces of Malaysia and Singapore, the RNZAF has shown New Zealand's desire to play an active role in keeping with its interests, in air defence, as in other matters in South East Asia.

The RNZAF today operates in three basic roles – combat, transport and maritime, with a training and support organisation to provide the facilities necessary for maintenance. Over the years, it has been shown that combat aircraft are the most rapidly effective and effective air contribution we can make in times of war and in pursuance of our collective defence commitments. Our Skyhawk Strike aircraft are fighter bombers which can be used in close support of troops, the counter-air role against airfields, or as interdictors against roads, lines of communication, supply convoys, or depots. The aircraft also have a useful air defence capability and can be used in an anti-shipping role. 75 Squadron, equipped with Skyhawks, became fully operational early this year and has already demonstrated its ability to operate effectively. No. 14 Squadron, equipped with Skyhawks, Vampire, and Harvard aircraft, is responsible for jet conversion and operational training of pilots destined for No. 75 Squadron. In addition, it trains pilots for duty as forward air controllers. The aging Vampires are reaching the end of their economic life and, in 1972, will be replaced by Strikemasters. 10 of these jet trainers have been ordered at a total cost of $7.8M. The first aircraft is due for delivery in April 1972 and, thereafter, at a rate of two per month until September 1972.

The transport role of the RNZAF reflects the fact that New Zealand is an island nation at a considerable distance from the areas where our forces are serving. We must, therefore, have the ability to move men and equipment by air over long distances. We must also provide for short-range transport and an air supply dropping capability. These roles are fulfilled by No. 40 Squadron equipped with Hercules C1-30 aircraft, No. 3 Squadron with Bristol Freighters, Iroquois, Sioux, and Wasp helicopters, and No. 41 Squadron based in Singapore with its current strength of two Bristols and three Iroquois.

New Zealand is a maritime nation. We rely on the sea for our trade, so there is an obvious need for defence of our sea communication. The maritime role of the RNZAF is provided for by No. 5 Squadron equipped with Orion aircraft, whose task is maritime reconnaissance and anti-submarine warfare in association with the RNZN frigates. These roles, therefore, are wide-ranging. But they are by no means a fully comprehensive programme of air activity. This would be quite beyond our resources. Instead, emphasis is given to what we see as the most important operations. The ultimate purpose in defence is to be able to meet any situations that might arise. We have, therefore, developed specialised expertise in fields likely to be of major concern to New Zealand. Because we endorse the concept of collective security, we are able to make our contributions in an area of immediate concern. We can then hope to draw on our allies for their expertise and effort in areas where we cannot contribute.

This brings me to a point I would like to emphasise. The RNZAF Orions train constantly in convoy protection duties with the frigates. Their two weapons systems – torpedoes and depth charges – are inter-related. The work of research scientists at the Defence Scientific Establishment at Devonport, which is engaged in complex investigations into under-water sound propagation, also has an obvious connection with the role of the Orions and frigate force. The point here is that the efforts of the Services are coordinated and inter-related. This is essential for a small force and is also the basis of modern management. The RNZAF Training Group is responsible for all basic flying training and ground training carried out within the Service. Its new Flying Training Wing is equipped with Devon, Harvard, Airtourer, and Sioux aircraft. Apart from its crucial role in maintaining the efficiency and standards of the Force, it has provided training for air force personnel from Malaysia and Singapore. This form of aid is most valuable in helping our two Asian partners to attain self-sufficiency in the defence field and complements the assistance our Forces are providing in the area itself.

Apart from the RNZAF's defence role, the Service is also playing an important part in civil activities. Its tasks have included the observation of the activities of foreign fishing vessels in the New Zealand area, search and rescue, participation in civil defence exercises, internal transport operations, VIP flying, the supply of isolated meteorological stations, transport of men and supplies to the Antarctic, and assistance to other Government departments, varying from cloud seeding operations in time of drought, to observation of volcanic activity on White Island. In the past, the RNZAF played a significant part in the development of aerial topdressing and also maintained patrols over forest areas for firefighting purposes. In the past year, in respect of relief aid overseas, RNZAF aircraft have made four flights to Calcutta carrying relief supplies for refugees from East Pakistan, and two additional flights are planned this month. The RNZAF has flown blood plasma to Cambodia, has carried 25 tons of sweet corn to South Vietnam. RNZAF aircraft have continued to resupply Qui Nhón and Bồng Sơn hospitals on a weekly basis, and have also carried materials for the Red Cross and other welfare organisations in South Vietnam.

Another form of assistance the RNZAF is providing in the civil field is to the Air Training Corps as part of the Government support for cadet training. Government's decision to support non-regular cadet activities up to a maximum expenditure of $400,000 per annum reflects the value it attaches to this type of disciplined activity in providing flexible leaders among young citizens of the country.

Expenditure of $400,000 in any one year on the cadet programme may not sound a great deal in relation to the defence appropriation of over $100,000,000. But Defence, like any other Government activity, must keep a tight rein on expenditure, and all activities must come under close scrutiny because all in effect are options. Nearly 60% of the Defence vote now goes to cover the wage bill. Much of the rest is committed to long term maintenance programmes or capital equipment purchases. In other words, when trying to limit increases in expenditure, each item must be examined against overall defence priorities.

In addition to the 1,100 officers and cadets in 15 of the 29 schools with cadet units, there are now 2,100 officers and cadets servicing with Air Training Corps Squadrons. I have recently authorised the formation of No. 16 Air Training Corps (ATC) Squadron at Tauranga, giving a total of 41 squadrons located in cities and towns from Kaitaia to Invercargill. The limit of $400,000 on cadet activities has meant that some economies have had to be made. These have included some reduction in regular force instructor strength and payments to officers for parade attendance. However, there has been no restriction on training activities. Defence support includes officer and cadet NCO courses, flying scholarships, overseas flights, cadet electronic and engineering appreciation courses, gliding adventure and aero modeling camps, and visits

PR6020 – NO. 40 SQUADRON HERCULES NZ7003 BEING UNLOADED IN ANTARCTICA, DURING OPERATION ICE CUBE.

to RNZAF bases. A total of 700 ATC cadets will attend courses and camps during the year. 1,700 cadets are authorised to visit RNZAF bases. There are regular visits by cadet force staff for the purpose of guidance, coordination, liaison, and instructional assistance.

In addition to Defence support, the recently formed Air Cadet League of New Zealand – which includes representatives from the Air Force Association and other organisations – has been established for the primary purpose of supporting the Air Training Corps. ATC squadrons are backed by active support committees with a chairman and executive to develop and support supplementary squadron activities and to raise finance for approved projects. I am confident that the new cadet scheme will work. The enthusiasm of the cadets, combined with the guidance and assistance provided by your Association and other interested organisations and individuals, will combine with Government finance and Service training into a worthwhile youth organisation. I should like to pay tribute to the reasonable and practical way in which officers of the various associations, and particularly your own, have helped in working out the basis for the new scheme.

I have emphasised that the Defence vote must meet a range of wide tasks. By world standards, our armed forces are small, yet, as will be evident from my survey of the activities of the RNZAF, we maintain many roles. In addition to the main purpose of providing for national defence and security, the armed forces provide a wide range of assistance to the community at large. But we must keep their main purpose – defence – in mind. The size and shape of our armed forces may not be perfect. I am reminded of the comment of the American designer, Raymond Loewy, that the only two

OHG3480 – NO.1 SKYHAWK CONVERSION COURSE.

shapes that could not be improved are those of the egg and the coca-cola bottle. The point I am making, of course, is that our Defence must be tailored to meet our needs and resources.

As you know, Government has had to take measures to restrain the rate of increasing expenditure. Defence expenditure in 1971/72 is likely to increase by at least 4%. While this will maintain our basic military capability, we have had to impose economic measures in all services, and the RNZAF has had to bear its share of the burden. The Government is, however, determined to stand by its international security commitments and obligations. We shall not lose sight of that objective. In 1921, Sir Henry Wigram sponsored a nation-wide essay competition, the subject being ‘the use of Aircraft in the Defence of New Zealand’. His object was to help promote what he termed the “crusade” to make full use of an air force for national defence. The winning entry by an Army Ordnance Officer, Captain Ivory, referred to a number of considerations affecting Defence policy, which are as valid today as they were at that time. “We cannot protect ourselves against all comers”, he wrote, “and must always look to the mother country for aid and help. However, as we enjoy all the sweets of self-government and self-determination and it is only fitting that we should shoulder our fair share of the responsibilities. An air force is as vital to our national existence as an army and navy, and our surest protection is preparedness.”

The principle of taking a share of responsibility is embodied in the concept of collective security, which is the basis of our Defence policy today. Preparedness is essential if we are to preserve our own security and national interests and fulfil our obligations.

This is a time of rapid, almost bewildering change. No one can predict what the future will hold. Great power relationships in the Asian and Pacific region are now more fluid than at any time since the Second World War. As the British presence has been reduced, and as the United States in the context of the Nixon doctrine is looking to the countries of the region to bear the primary responsibility for their own defence, other influences are growing. The Soviet Union appears intent on extending its maritime as well as its political activities in the area. Japan is playing an increasingly active role, a reflection of its phenomenal economic growth. Communist China’s foreign policy is showing increasing flexibility and its admission to the United Nations means that Peking will soon be exerting its influence on a much wider stage. Southeast Asia, despite impressive progress in some countries, remains an area of tension and is subject to continuing subversion and insurgency.

For our part, we have demonstrated our readiness to accept some of the burden of the fundamental problem, which is security. I believe we must continue, to the best of our limited resources, to help our Asian and Pacific neighbours to develop their capacity to cope with security problems. Our armed forces are playing an important part in the establishment of relationships of trust and confidence in our Asian and Pacific environment. That they are able to do so is evidence of the value of preparedness. We must ensure that we have efficient, well trained, and well-equipped forces if we are to contribute to the collective defence of our region. And it is in this area that the RNZAF will continue to have a vital part to play.

Minister of Defence,
The Right Honourable David Thomson
to the New Zealand Air Force Association
5th November 1971.

PILOT GRADUATION,
OHAKEA, NOVEMBER, 2019.

MODERN CONCEPTS IN AEROMEDICAL EVACUATION FOR THE NZDF

SQNLDR ROB VISSER | BASE MEDICAL OFFICER
ROYAL NEW ZEALAND AIR FORCE BASE OHAKEA

AUTHOR BIO

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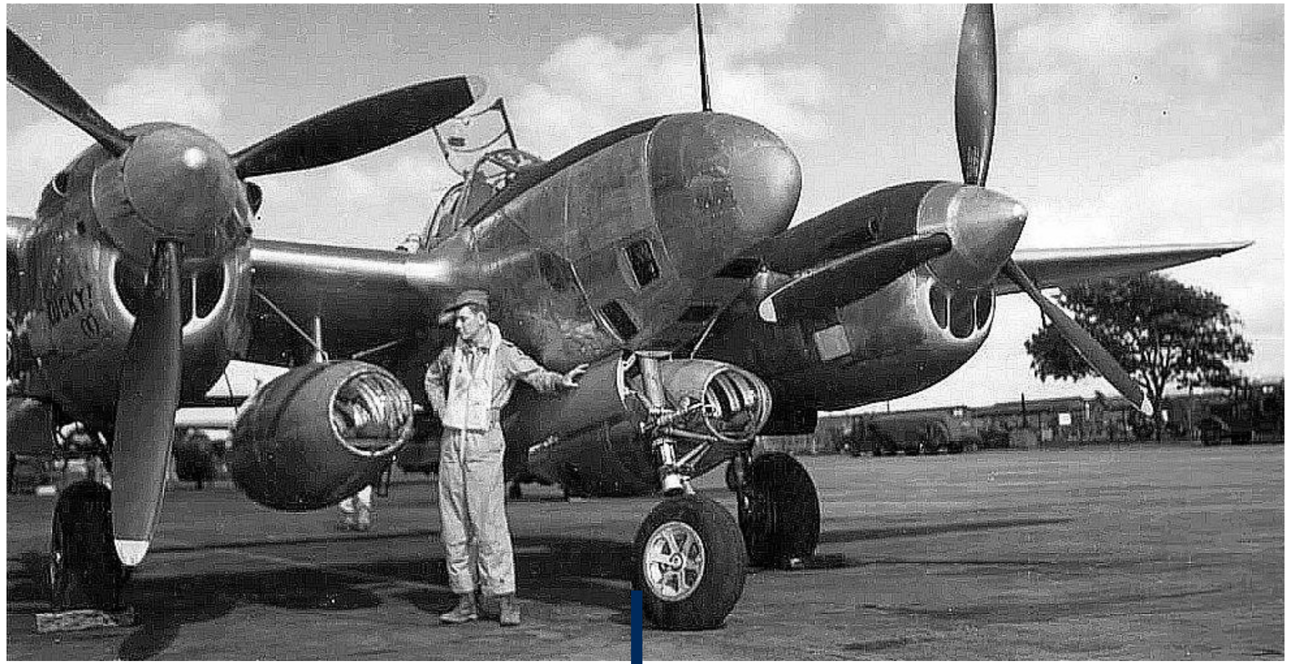
BACKGROUND

The history of military aeromedical evacuation (AE) dates back well over a century, with the first verifiable recorded medical evacuation flight of a wounded Serbian soldier carried out in 1916, aboard an un-modified French fighter. One year later in 1917, a British soldier in Turkey was flown to hospital with a gunshot wound to the ankle, turning a 3-day trek into a 45-minute flight – epitomising the advantages of aeromedical evacuation. Around the same time, the Reverend John Flynn proposed the original concept of a 'mantle of safety' for outback Australia, which spawned the Aerial Medical Service, now known as the Australian Royal Flying Doctor Service. During subsequent decades, the frequency with which militaries utilised AE increased rapidly. World War II heralded a rapid advancement of military casualty evacuation systems by air. Only in 1942, however, did the United States first begin training flight transport personnel to provide specific medical escort duties in flight. It was recognised that the stress of flight and the unique effects of altitude and hypoxia had increasingly detrimental effects on wounded casualties, presenting unique challenges for medical crews. Over the years, as the level of clinical care and AE experience increased, survival rates of casualties transported by air also increased. Dedicated AE systems have grown in number and complexity in the last half of the 20th century. Certainly, by the 1970s and 1980s, driven by experience in the Vietnam War, civilian healthcare systems recognised the value of AE and took the lead in developing highly specialised teams and systems. This process in New Zealand has, to a great extent, replaced the traditional search and rescue (SAR) and medical evacuation (medevac) roles provided by the RNZAF. Currently, in New Zealand, the dedicated civilian helicopter and fixed-wing air ambulances – mostly staffed by mixtures of specialised paramedic, doctor, and flight nurse teams – provide our civilian population with a world-class AE system. Civilian AE systems are designed around the concept of providing the highest available level of care to single patients in controlled settings, where this provides the patient with the best mix of specialist skills and time savings. Ideally, this is measured against a background of cost-effectiveness, clinical and financial benefits for the patient and population.

Military AE, on the other hand, is often carried out for different reasons and in different circumstances. Where civilian AE is usually only beneficial, compared to ground transport, over longer distances (50-200km) and for more complex patients, forward military AE may be conducted over much shorter distances, even for relatively minor casualties. The drivers for military AE include terrain and access, threats to ground transport, availability of ground transport near the point of injury (POI), multiple casualties, and multiple POI within the area of operation. A well-designed and resourced military AE system may also offer the benefits of higher levels of clinical care, however, where and



CASEVAC POD ON A P38 LIGHTNING, WORLD WAR II PACIFIC THEATRE.

when this is employed needs to be carefully considered by commanders. For example, there would be few benefits of utilising a critical care transport team to collect multiple casualties from a POI for a 15-minute flight to a Role 2 (damage control forward surgical) facility. A critical care team would have little time, or ability, to administer advanced interventions beyond what well-trained medics could provide during a short flight. The priority here is to sustain life with immediate basic life support and control of haemorrhage.

AEROMEDICAL EVACUATION WITHIN THE CONTINUUM OF CARE

The continuum of care for an injured soldier starts with self-aid and buddy aid to control immediately life-threatening bleeding and airway threats with simple procedures. Role 1 care (resuscitation unit) provided at or near the POI aims to further stabilise the casualty and prepare them for evacuation rearwards, often by the rotary-wing platform. Enroute medical care is focused on addressing immediately life-threatening injuries and bleeding, but also begins definitive treatment, which not only aims to save lives but aims to reduce the impact of the injury due to pain, suffering, and long term complications. Modern military field hospitals (Role 2) now provide damage control resuscitation and surgery, adding components of life and limb saving care at ever-increasing levels of complexity. By the time a seriously injured soldier has been stabilised in a Role 2 facility, they may be receiving care comparable to an intensive care unit, utilising a multitude of specialised equipment, medications and treatments to maintain life. The continued function of these medical facilities relies on the onwards transport of casualties as soon as possible to free up resources for subsequent patients. Specialist medical colleges in Australia govern the standards of care and scope of practice for the management and transport of critically injured casualties:

> *"As a guiding principle, the level of care provided during transport must aim to at least equal that at the point of referral and must prepare the patient for admission to the receiving service."*

This ever-escalating level of care must also be reflected in the care provided in flight. Maintaining or improving the level of care throughout evacuation is a fundamental concept in AE. It forms the basis of both military and civilian AE standards throughout the world and is encompassed in the 'medical worthiness' concept, emphasised equally alongside airworthiness as components of a safe and sustainable AE system.

AIRWORTHINESS AND MEDICAL WORTHINESS

Almost all aeromedical evacuation systems can trace their history back to a time and place where initial flights were carried out on transport or combat aircraft, often without specialised equipment, and at times without any medical care or attendants. Some extreme examples include pods carried under the wings of fighter aircraft or baskets attached to the skids of helicopters. These systems offered only transport, with no medical care, and minimal protection from the stressors of flight. In the 21st century, however, this is no longer an acceptable solution to the transport component in the casualty continuum of care.

The components of a modern military AE system include; specialised medical portable electronic devices (MPEDs), patient handling and restraint systems (stretchers/litters), specialised medical and flight safety training, and standard operating procedures for the medical attendants. The integration of these components with the aircraft and aircrew requires a coordinated and planned approach, based on a solid concept of operation to deliver a sustainable and safe operational effect.

Increasingly complex MPEDs and systems – used to support life during AE – expose both the patient and the aircraft systems to real and theoretical risks due to their effects on each other. The military aviation setting contains a range of complex communications, threat sensing, and electronic warfare systems, as well as electronic flight control systems that may be affected by, or even affect, MPEDs. In the worst-case scenario, if these potential effects are unquantified and untested, aircraft systems or the patient may be adversely affected by catastrophic outcomes. Other medical systems such as compressed or liquid oxygen can pose an added risk in flight, and many MPEDs rely on some form of external power to ensure prolonged use. Patients do not routinely travel in seats, and seats are not designed to safely restrain MPEDs or medical packs, therefore systems and procedures to achieve these requirements need to be developed. Several airworthiness standards govern the integration and testing of MPEDs with specific platforms, as well as standards for restraint of patients, litters, and medical equipment in flight. In the RNZAF – like many other modern militaries – our aircraft are unlikely to be dedicated to the AE role; instead, rapid reconfiguration as an AE platform using a flexible system of casualty and equipment restraints will be the norm. This is consistent with many other nations who also achieve this with the use of standard NATO litters and a sensible approach to safe restraint of equipment to deliver an effect. Other larger military AE systems have the benefit of dedicated aircraft, where the AE and patient loading systems can be fitted or built into the aircraft.

Medical personnel providing in-flight care are usually considered to be staff crew, more so in most military AE systems. This recognises that medical crew members also need specialised training in aviation medicine, critical care resuscitation, aircraft safety and survival procedures, and how to work alongside the aircrew to deliver a safe casualty transport system. As part of the crew, medical personnel are exposed to the same risks and environments as the aircrew. They are expected to be afforded the same protection and equipment to safely operate in the aircraft and increase their ability to survive an accident or respond to threats. The concept of medical worthiness of an AE system reflects all of these considerations. It recognises that the medical components of the complete system must be developed in parallel with the airworthiness components and that the quality of clinical care meets accepted medical standards.

STANDARDS AND INTEROPERABILITY

In New Zealand, air ambulance standards exist across a number of governing bodies and are reflective of international civilian guidelines or standards of care. Equally, both from NATO doctrine and Five Eyes Air Forces Interoperability Council focus, there are several Standardization Agreement (STANAGS) and Advisory Publications which aim to support the development of interoperable AE systems within coalition militaries. Currently, the focus is on ensuring that AE systems,

RNZAF ROTARY WING AEROMEDICAL EVACUATION TEAM ON BOARD AN NH90, COMPLETING A TRAINING EXERCISE.

equipment, and people can be utilised across a range of coalition platforms. Ideally, this can be achieved to the point where airworthiness MPED clearances and medical personnel credentialing is accepted by both the airworthiness authorities and medical governance authorities from each of the coalition members.

A well organised military AE system must address the medical and airworthiness aspects to ensure that safe SOPs are developed and followed during permissive (peacetime) operations. When an AE system is required to then operate in environments of increasing threat, these processes need to be matured enough to the point that crews can make operational decisions under pressure to balance imminent operational threats with the need to safely treat and transport their casualties. Only real-time exposure in permissive environments or exercises can provide this experience. In New Zealand, this should include regular integration with civilian AE systems to provide this clinical experience and more comprehensive involvement of the developing AE capabilities in domestic and overseas exercises.

MODERN CONCEPTS IN AE

In the last ten years – driven by experience in world conflicts – there have been tremendous developments in evidence-based medicine, healthcare technology, and aircraft systems. These now present us with unprecedented capabilities to bring advanced resuscitation and lifesaving skills to ill and injured soldiers on the front line. This same technology has already found its way into civilian AE systems, supporting many of the critical care resuscitation techniques used around the world. Instead of complicating the AE systems, these advances are making the process of AE simpler. Some specific examples worthy of further explanation include:

- oxygen delivery, oxygen systems and advances in ventilator technology;
- battery capacity of MPEDs; and
- utilisation of whole blood vs blood components.

OXYGEN DELIVERY, OXYGEN SYSTEMS AND ADVANCES IN VENTILATOR TECHNOLOGY

Since the mid-2000s, there has been a significant swing towards better target-directed oxygen therapy – rather than high flow oxygen – for all ill or injured casualties. As a result, once a casualty has received initial resuscitation, oxygen delivery is often significantly reduced. Ventilators used in AE – MPED which provide artificial breathing as part of a life support system – were traditionally driven by compressed oxygen, consuming up to 10 litres per minute in some cases. Modern ventilators being introduced around the world (including in the RNZAF) are battery-powered and turbine or pump-driven, utilising only a small fraction, if any, of compressed oxygen to support a patient. As a result, there is less need to carry large quantities of medical oxygen. How does this affect future AE? Medical oxygen is traditionally carried by the RNZAF as compressed gas in steel cylinders. There are three main concerns with this. The compressed oxygen is a potential fire risk in environments where flammable gases or liquids may be present, and where there may be a threat of a breach of either the cylinders, fuel tanks, or both. Although the number of cylinders needing to be emptied into an aircraft cabin to achieve a significantly oxygen-enriched environment is substantial, a leaking cylinder presents an extreme fire or explosion risk within the immediate vicinity of the leak. Steel oxygen cylinders are heavy and dangerous air cargo when it comes to resupply. To complicate matters, there are a number of different oxygen cylinder sizes and fitting standards around the world, meaning that compressed oxygen cylinders are not always compatible between nations or even between systems in the same nation. Heavy cylinders also present a missile risk if not adequately restrained. Reducing the oxygen requirements for AE will have significant positive impacts on future capabilities.

MASS CASUALTY TRANSPORT EXERCISE ON-BOARD RNZAF C130H(NZ).

BATTERY CAPACITY OF MPEDS

AE life support systems rely almost exclusively on electrical power, whether this is from an internal battery, external power pack or supplied via the aircraft electrical system. Legacy MPEDs rely on a variety of power supplies, with some designed specifically for the NZ/AUS 240 V 50Hz AC supply. Others are capable of being converted to 110-115 V 60Hz, 12 V DC, or 28V DC aircraft power supplies. No MPEDs are designed to use the high-frequency AC power delivered by many aircraft inverters, which can damage their internal batteries and lead to equipment failure over time. This has resulted in complex electrical support systems being designed to recharge or power MPEDs in flight. Some of these are commercially developed but deliver only US standard 115 V 60Hz AC; others are custom built with complex battery backup to support the unique suite of legacy MPEDs used by nations such as Australia and New Zealand. These systems also come with the cost of weight, complexity, and risk. A recent exercise in the US highlighted a wiring issue that caused a system short circuit and malfunction in a fixed-wing platform when a commercial medical power supply was turned on. This not only resulted in aircraft damage but also electrocution of an operator, highlighting the real risks of trying to integrate MPEDs with aircraft systems.

New Zealand is now leading the way in acquiring the latest AE-approved MPEDs. These new devices have a massively increased battery capacity, some lasting up to 8 hours on a single charge, and also where it counts, replaceable batteries. Not only that, but modern MPEDs have flexible and often standardised charging systems, able to use 110-240 V AC through standard plugs. This has reduced the reliance on aircraft power supplies and chargers to all but the longest of strategic AE flights.

This technology, however, comes with new hazards. There needs to be an awareness around the risk that high capacity lithium batteries may pose in flight, especially if damaged. This can be mitigated with better training and awareness, as well as ensuring spare batteries are packaged safely and inspected for damage before use or flight.

WHOLE BLOOD VS BLOOD COMPONENTS

Transfusion medicine (blood transfusion) is possibly one of the fastest advancing fields in pre-hospital critical care medicine and is a critical component of military and civilian AE systems. Experience over the last 20 years of conflict in the Middle East has seen the development of blood transfusion protocols requiring the use of increasing blood component ratios compared to the past. This came with significant logistic complexities with regards to the manufacture, transport and storage of blood in a deployed military environment. Traditionally, donated blood is separated into three main components used for the treatment of trauma: red blood cells, frozen plasma and platelets. Until military experience changed transfusion medicine 10-20 years ago, most blood used in the acute treatment of trauma was just the red cells on their own. These are relatively easy to prepare, transport and store at standard refrigeration temperatures. Time (and logic) has now shown that major trauma victims who need blood, need all the good stuff found in whole human blood. That includes the clotting factors found in plasma, which is stored at -35 °C, and platelets, which have a very short shelf life. Effective and safe massive transfusion now recommends that these components are given in a 1:1:1 ratio. The implications on manufacture, transport, and storage of these blood components to support military AE systems are complex and expensive. The last few years, however, have seen another quantum shift in pre-hospital and military blood transfusions. The evidence now coming out of war zones supports the use of whole blood, ideally *fresh*, warm whole blood. Now this seems logical and raises the question of how this should be transported and stored. The obvious answer would seem to be in the bodies of the blood donors who make up the support team on military operations. No more blood bank freezers, no more thawing equipment, no more complex logistic supply systems to maintain the cold chain if this blood can be donated, prepared, and utilised at the forward medical facilities.

MEDICAL EVACUATION EXERCISE WITH OTHER HEALTH SUPPORT ELEMENTS, SOUTHERN KATIPO, 2017.

Most importantly for AE, no need to carry multiple different blood components at different temperatures, and having to coordinate these components into an effective combination to treat critically injured soldiers. There is a flip side to this, and that is the risk of transmitting blood-borne infections. This can now also be relatively well mitigated with the availability of rapid point of care tests for the common blood-borne infections (that we know about). Most deployed military field hospitals will have some form of 'walking blood bank' or screened donor panel. Many of our soldiers, sailors and airmen who have deployed to locations in the Middle East in recent years will have been part of these donor panels.

A few of our coalition partners are experimenting with freeze-dried blood components, which may offer an even easier solution in the future. Of all the potential developments and advances in AE technology, the one hurdle currently facing the NZDF is the complexity around the supply and use of blood products. Hopefully, the changes in practice and potential new products on the horizon will simplify our systems needed for blood transfusion during AE and allow us to develop or plug into a blood product supply system.

THE FUTURE OF AEROMEDICAL EVACUATION WITHIN THE NZDF

The focus on military AE in New Zealand has only recently been reignited with a realisation that AE is a critical enabler of deployed operations in remote parts of the world. With the modernisation of RNZAF aircraft, our local and global reach for the delivery of aeromedical evacuation is beginning to be realised. While our fledgling capability lacks experience, we are close to the leading edge of AE when it comes to modern equipment, training and clinical standards. Our commanders require these capabilities to deliver modern, deployable and interoperable AE to support our missions and to complete the chain of evacuation within the continuum of care. There is also an expectation that when the New Zealand Government requires it, the NZDF can step up to support civilian healthcare and AE systems in times of disaster here at home.

The NZDF, like many of our coalition allies, is too small to focus on dedicated teams and capabilities for each phase of AE or individual platforms. Rather than this being regarded as a weakness, however, we should understand that it offers the potential to develop a flexible and more experienced NZDF approach to AE. The skillset, equipment, and patient requirements are similar from POI through the evacuation chain to definitive care in New Zealand, regardless if this is delivered on a forward rotary-wing AE platform, a fixed-wing tactical or strategic AE, or even land or maritime-based casualty transport systems. The future of AE capability development in New Zealand will continue to need a platform-agnostic approach, utilising similar and interoperable equipment sets, and common training pathways that are consistent with our coalition allies but, more importantly, interoperable between our own three services.

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OPERATION MOA,
3 SQUADRON.

SMRPA, SMRMP, ASCC, EMAC: SO WHAT'S IN A NAME?

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AUTHOR BIO

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INTRODUCTION

Good order at sea may not be the first thing that springs to mind when thinking about the Air Force – usually being considered the *raison d'être* of the Navy. However, New Zealand's unique geostrategic circumstances have required the Air Force to play a major role in supporting the Navy in maintaining good order at sea. Now that the future air surveillance capability (FASC) for the New Zealand Defence Force has been confirmed, and the training and infrastructure phases are under way, it is timely to examine some of the consequences of this decision, and specifically how it will affect maritime domain awareness within our own territorial waters and Exclusive Economic Zone (EEZ). The scope, size, value, and importance of New Zealand's EEZ is well documented in detail elsewhere[1] and need not be repeated here. Maritime domain awareness is the desired outcome of maritime surveillance, in other words, being aware of what is happening in our maritime area of interest. So what is maritime surveillance and why is it important?

New Zealand's ocean areas are a valuable resource that provide significant income and employment, and their value to New Zealanders are likely to increase in the future, especially with the potential for mineral resource exploitation and an ever-increasing demand for fish. New Zealand's ocean areas are also its lifeline, with the great majority of its commerce transported along the highways of the sea – otherwise known as 'sea lines of communication'. The Government has a fundamental need to assert and protect its sovereignty over these ocean areas, including the waters and resources of the EEZ. Maritime surveillance supports national assessments and decision-making on a number of issues, including security, military commitments and tasking, resource protection, border control, terrorist threats, and disaster relief.[2] Maritime surveillance, both aerial and surface, is a major contributor to New Zealand's independent intelligence gathering process, by both contributing and acting on intelligence. When available, air assets can usually be deployed relatively quickly and can provide information on specific targets to a degree of resolution and quality necessary for prosecution or diplomatic intervention. The Government needs to know what is happening in this key strategic area and surveillance tells us who is out there and what they are doing. Maritime surveillance is basically concerned with the protection of sovereignty and is vital to the national interest. Maritime surveillance then, is the

1 Moremon & Oliver, "Air Surveillance Capability and the Security of the Excusive Economic Zone."

2 Department of the Prime Minister and Cabinet, *Maritime Patrol Review*, 6.

systematic observation of areas of interest in the maritime domain. The desired outcome of surveillance is heightened awareness, and, in the case of maritime surveillance, this is referred to as maritime domain awareness (MDA). This essay will focus on the airborne aspects of MDA in New Zealand's territorial waters.

MARITIME SECURITY – WHO IS RESPONSIBLE?

Home security is the responsibility of government. There are two main areas of concern to New Zealand in the context of the maritime environment; border control and a complementary maritime strategy, with the goal being to control the movement of people and goods into and out of New Zealand via secure lines of communication. New Zealand has strict border controls in place to monitor and control the movement of people, though, like the rest of the world, scrutiny of goods is relatively marginal. A robust maritime strategy is fundamental to New Zealand's security and economic well-being; any interruption to New Zealand's sea-lanes could be disastrous. Likewise, the extent and cost to New Zealand of illegal, unregulated, and unreported fishing activity is simply not known due to a lack of resources to find out. The introduction of the Naval Patrol Force in 2010 held great promise to cover some deficiencies in surface aspects of maritime surveillance. However, for various reasons, the inshore patrol vessel (IPV) element never met its potential, and its future is uncertain. The IPV concept was always somewhat of a mismatch for the Navy, and was an outcome of the contemporary Government's desire for increased utility of New Zealand's armed forces – particularly with regard to co-operation with other government departments, that is to say, in support of civilian authorities with civilian issues. The problem with this was the danger that an element of the Navy would become entrenched with the typical roles of a coastguard, and thus, become a coastguard force by default, offering limited use to a warfighting Navy.[3] Regardless of what form a future EEZ surface element may look like, without regular and persistent aerial surveillance, the vessels will be operating virtually blind, though still enabling a low level of deterrence just through its existence. Aerial surveillance would be the essential eyes and ears enabling any surface element. The *Defence White Paper* of 2016 outlined New Zealand's strategic priorities, and clearly states that 'Government's highest priority for the Defence Force is its ability to operate in New Zealand and its Exclusive Economic Zone, followed by the South Pacific and the Southern Ocean.' [4] Yet it appears that the New Zealand Defence Force is largely structured around a small land expeditionary force in support of coalitions, which is not particularly helpful in this context. Supporting an adequate maritime surveillance strategy will require significant capital costs, either new or a reallocation of funds, and perhaps a specialist organisation to run it.

At the time of writing, New Zealand does not have a national security strategy, nor a maritime security strategy or policy specifically, though the elements of such are more or less woven throughout various pieces of legislation and government policy. The New Zealand government takes an 'all hazards – all risks' approach to security. This *realpolitik* approach is a sensible one, as New Zealand is exposed to a variety of natural hazards as well as traditional low-level security threats that could disrupt our way of life. It is impossible to even consider what every eventuality might be, let alone prepare for them. To mitigate this, New Zealand takes a holistic and integrated approach to managing national security risk, as expressed in the National Security System (NSS) Handbook.[5] Known as the four Rs, this encompasses: '*Reduction*, through identifying and analysing long-term risks and taking steps to eliminate these risks if practicable or, if not, to reduce their likelihood and the magnitude of their impact.

3 Rahman, *Concepts of Maritime Security: A Strategic Perspective on Alternative Visions for Good Order and Security at Sea, with Policy Implications for New Zealand.*

4 Ministry of Defence (NZ), *Defence White Paper 2016*, 11.

5 DPMC, NSS Directorate, *National Security System Handbook*.

A NUMBER OF THIRD-PARTY AEROSPACE COMPANIES OFFER CONVERSION OF EXISTING CIVILIAN PLATFORMS SUCH AS THIS EXAMPLE OF A DASH 8 Q300 COMMUTER — FITTED WITH SEARCH RADAR, EO/IR, SATCOM AND DISPENSING SYSTEM. THE DASH 8 Q300 REPRESENTS A CREDIBLE MARITIME SURVEILLANCE MACHINE.

Readiness, through developing operational systems and capabilities before an emergency happens. *Response*, by taking action immediately before, during, or directly after a significant event. And *Recovery*, through coordinating efforts and processes to bring about immediate, medium-term, and long-term regeneration'. A range of national plans and guidelines exist that cover various categories of events and who would be the lead agency in responding to these events, such as the Ministry of Health in a pandemic situation, National Emergency Managment Agency (NEMA) for a major earthquake, Maritime New Zealand for a maritime incident, etc. An Auditor General's report from 2010[6] identifies six 'core agencies' that have an interest in maritime security and thus are users of the maritime domain intelligence supplied almost exclusively by the New Zealand Defence Force. These core agencies are: New Zealand Customs, Ministry of Primary Industries (Fisheries), the Department of Conservation, the Ministry of Foreign Affairs and Trade, the New Zealand Police, and Maritime New Zealand. These various government departments imply a strong regulatory and law enforcement focus – there being little, if anything, of particular interest to the military.

SO WHAT IS MARITIME SECURITY?

With so many interested parties, maritime security is different things to different people and organisations. For instance, Maritime New Zealand is largely concerned with monitoring and enforcing compliance with the Maritime Security Act 2004, which in turn brings into legislation the requirements of the International Ship and Port Security (ISPS) Code. The ISPS Code, which New Zealand has adopted, represents international best practice that enhances the security of ships and port facilities.[7] Maritime New Zealand is also responsible for maritime search and rescue coordination and is the lead agency for any response to major maritime incidents – such as a major oil spill – all on a budget of around $50m.[8] Whereas Fisheries New Zealand[9] is primarily concerned with sustainably managing fish stocks and enforcement of fishing regulations. Regardless of what your main interest is, you need to know what is happening in the maritime domain, and this requires information. In an overarching sense, the United Kingdom's government noted that, within the context of a maritime strategy, maritime security is: 'the advancement and protection of the UK's national interests, at home and abroad, through the active management of risks and opportunities in and from the maritime domain, in order to strengthen and extend the UK's prosperity, security and resilience and to help shape a stable world'.[10] While somewhat broad, this definition does contain what are perhaps the key elements relative to New Zealand's EEZ, those of protection of national interests and management of risks and opportunities. National security is 'the condition that permits the New Zealand citizens to go about their daily business confidently, free from fear, and able to make the most of opportunities to advance their way of life'.[11] It is a straight-forward mental exercise to overlay this statement specifically into New Zealand's territorial waters and EEZ. Of the objectives that underpin the 'all hazards' approach to national security, four are of direct relevance to the maritime domain. These are: preserving sovereignty and territorial integrity by protecting the physical security of citizens, and exercising control over territory consistent with national sovereignty; protecting lines of communication, both physical and virtual, that allow New Zealand to communicate, trade and engage globally; sustaining economic prosperity through maintaining and advancing the economic wellbeing of individuals, families, businesses and communities; and protecting the natural environment by contributing to the preservation and stewardship of New Zealand's natural and physical environment.[12] We can perhaps narrow these objectives down to two functions: ensuring the free maritime passage of people and goods, and ensuring adherence to maritime law and regulations governing the commercial exploitation of New Zealand's maritime resources. As Chris Rahman suggests,[13] there is very little new at the core of maritime security, and many so-called 'non-traditional threats' are, in fact, historically traditional issues that, for most navies, rise and fall 'depending on the threat environment of the day'.[14] Rahman also reminds us that Geoffrey Till's [15] development of the idea that maritime security has at its core 'good order at sea' – this sums up the point of maritime security precisely.

MARITIME SURVEILLANCE AIRCRAFT OR MARITIME PATROL AIRCRAFT?

An issue with the project to find a P-3 replacement was the name of the project itself, Future Air Surveillance Capability (FASC). Surveillance is one function of the intelligence and situational awareness role, but there is a great deal more to the FASC or, as we now know it to be, the P-8A Poseidon, than just surveillance – contrary to what the name seems to imply. In general terms, the intelligence provided by air platforms, manned and (increasingly) unmanned, and space-based sensors significantly contributes to reducing uncertainty in the decision-making process and improving the ability to gain and maintain information superiority, which in turn increases flexibility, enhances effectiveness, increases responsiveness, aids force protection, and – above all else – contributes to situational awareness.[16] And while surveillance, or the collection of intelligence,

6 Controller and Auditor-General, *Effectiveness of Arrangements for Coordinating Civilian Maritime Patrols.*

7 Maritime New Zealand. "Maritime Security: What We Do."

8 Maritime New Zealand, Briefing to Incoming Minister, October 2017.

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10 Ministry of Defence (UK), *The UK National Strategy for Maritime Security.*

11 Ministry of Defence, *Strategic Defence Policy Statement 2018.*

12 DPMC, NSS Directorate, *National Security System Handbook.*

13 Rahman, *Concepts of Maritime Security: A Strategic Perspective on Alternative Visions for Good Order and Security at Sea, with Policy Implications for New Zealand.*

14 Ibid.

15 Till, *Seapower: A Guide for the Twenty-First Century.*

16 *New Zealand Military Air Power*, NZADP-D (draft), APDC.

is an essential element of the capability that the P-8 will bring, probably more important is the maritime patrol element of the overall capability. So, it would be useful to differentiate between maritime surveillance (MARSURV) and maritime patrol (MARPAT), because they are different. The recent thinking in NATO – and thus one presumes its member air forces, which includes those who are Five-Eyes and Air Force Interoperability Council members and thus our military partners [17] – is that MARSURV includes all aspects of maritime-related intelligence, surveillance and reconnaissance (ISR), and maritime domain awareness, which contributes to a comprehensive surface picture by the use of visual or electronic means, such as electro-optical systems, radar, and in the case of search and rescue (SAR), quite often just scanning by eye. MARPAT, on the other hand, covers all aspects of maritime surveillance with the addition of anti-submarine (ASW) and anti-surface warfare (ASuW) capability [18] – in other words, having the ability to detect and track submarines while also having the ability to engage both sub-surface and surface targets, with depth-charges, missiles, and torpedoes as required, carried out by maritime patrol aircraft (MPA). Modern MPAs also have at least a basic electronic support measure (ESM)[19] and communications relay function. The P-8A is an uncompromising high-end MPA, designed primarily for warfighting – everything else is incidental and secondary to its military roles. Though, as was previously noted, MARSURV – in the context of sovereignty – largely has the EEZ as its focus and therein lies the problem.

The RNZAF are replacing six P-3 Orion aircraft with four P-8 Poseidon aircraft, a fleet reduction of a third. There are various arguments put forward as to why this is not an issue. Firstly, it is argued that serviceability, and thus availability, will be greatly enhanced with new aircraft, and secondly, that the new aircraft, being fitted with the latest advanced systems for the collection and fusion of data, will provide enhanced levels of capability in MARSURV and MARPAT roles. Evidence from US sources has been somewhat varied with regard to the reliability of the P-8. Next generation commercial Boeing 737 aircraft – of which the P-8 is a hybrid with regard to airframe and flight systems – were claimed to have a despatch reliability [20] of 99.7% during Q1 of 2019,[21] and there is no reason to doubt this, as airliners are amazingly reliable.[22] In mid-2019 Boeing also claimed a despatch reliability of 95% for the P-8,[23] which, to the contrary, would be astonishing for a military aircraft, especially a recently introduced one. This claim may seem somewhat generous, perhaps implying a metric of despatch availability of the basic airframe – discounting on-board military systems that are extremely complicated. This was borne out in a report released by the Pentagon's Office of the Director of Operational Test and Evaluation in early 2019, which stated that there were major issues, with some operational systems requiring increased maintenance, which were further exacerbated by a lack of spares and a lead-time of six to nine months; consequently aircraft in non-operational areas were being 'cannibalised' for parts to sustain operational deployments.[24] Readers familiar with engineering support and logistics will recognise these state of affairs, though it is usually just a matter of time until things improve. The point is that it all puts pressure on a very small fleet – this was acknowledged in the Strategic Defence Policy Statement (SDPS), [25] by noting a mix of capabilities may be required to enhance MDA. This was subsequently addressed to a degree in the Defence Capability Plan (DCP).[26]

The SDPS is unequivocal in stating: 'The Government's highest priority for the Defence Force is its ability to operate and undertake tasks in New Zealand's territory (including its EEZ) and its neighbourhood…' Further stating that maritime surveillance is one of the main activities that will be carried out. The following section of the SDPS lists the 'Principal Roles of the Defence Force'. The first listed is to 'defend New Zealand's sovereignty and territory, and contribute to protecting New Zealand's critical lines of communication'. While no hierarchy is explicitly stated, it is strongly implied that this is the principal role, in-line with Defence priorities. It is perhaps conjecture to assume the use of the word *defend* is quite deliberate, rather than the more passive *protect*. Defend means to resist (usually with force), whereas protect means to keep safe from – subtle, but quite distinctive. For instance, to use the analogy of someone's dwelling; you install a burglar alarm to protect your home, but use a shotgun to defend it. The New Zealand Defence Force is the only organisation both capable of, and mandated to, defend New Zealand. While there is no clear and present threat, we default to protecting, which does not necessarily require a warfighting capability. To protect – in the context of sovereignty in peace time – implies a requirement to monitor, ensuring the rule of law is maintained within our territorial areas of responsibility. In other words, everyone, from the government down, goes about their business in a lawful manner, free from hindrance or interference, and so it is with New Zealand's maritime territory and areas of interest beyond. This strongly implies a policing role – to ensure compliance with civil/maritime law – and raises the question of whether we need a $250m MPA, that is principally a high-end warfighting machine, to do this. The short answer to that question is probably no, and the DCP has recognised this, stating a need for 'enhanced air surveillance capabilities', which would be dedicated to civil surveillance tasks. This statement was given specific shape under the heading of 'Investment Decisions Planned for 2020' and a new name, 'Enhanced Maritime Awareness Capability,' or EMAC. The DCP further stated that: 'the Enhanced Maritime Awareness Capability project will support the Government's civil maritime security strategy, providing air surveillance capabilities that enhance all of government maritime domain awareness in New Zealand and the Southern Ocean. The capabilities delivered through this investment will be dedicated to civil surveillance requirements, with Defence support for their delivery and operation. This will free up the new P-8A maritime patrol aircraft fleet to fly more missions in the South Pacific and further afield.

17 Being the US, the UK, Australia, and Canada.
18 Joint Air Power Competence Centre, *Alliance Airborne Anti-Submarine Warfare: A Forecast for Maritime Air ASW in the Future Operational Environment*, 10-11.
19 ESM is a function of ISR in that the product contributes to the overall intelligence picture.
20 That is to say, left the gate within 15 minutes of scheduled departure time.
21 Boeing, "737 Max: About the Boeing 737 MAX."
22 Mainly due to the fact that there are no 'mission' systems as such, and the use of minimum equipment lists.
23 EDR On-line, "MPA and AEW&C 737 Derivatives: Looking for New Orders."
24 Business Insider Australia, "The US Navy's Best Sub-Hunting Aircraft Faces Some Nagging Problems."
25 Ministry of Defence (NZ), *Strategic Defence Policy Statement 2018*.
26 Ministry of Defence (NZ), *Defence Capability Plan 2019*.

Investment in a range of capabilities will be considered, including satellite surveillance, unmanned aerial vehicles (UAV) and traditional fixed-wing surveillance.' It also gave an indicative introduction into service (IIS) date of 2023 and costs in the region of $300-$600m. The first thing to note is that satellite surveillance is not air surveillance and, accordingly, will not be considered in detail. Operationally, air and space are quite discrete environments; though the boundary is perhaps not as well delineated as air-land, air-sea etc. Until the point is reached where movement between the air and space can be carried out at will, space power is best regarded as being discrete but complementary to air (and land, and sea) power, sharing many of its attributes – in a distinct way – at a very different scale. Air power and, by default, air surveillance encompasses that which flies.[27]

THE IRISH AIR CORPS HAS ORDERED TWO AIRBUS C295 AIRLIFTERS CONFIGURED FOR MARITIME SURVEILLANCE.

MARITIME PATROL REVIEW 2001 – BACK TO THE FUTURE

The requirement for a short-medium range maritime surveillance aircraft to patrol New Zealand's territorial waters was first raised, officially, in the Maritime Patrol Review of February 2001.[28] The Maritime Patrol Review (MPR) is the most thorough examination of New Zealand's maritime patrol requirements ever carried out and is no less relevant despite the passing of 19 years since its publication. The objectives of the review were explicit and telling, and are worth stating in full. Specifically it was to:

1. examine New Zealand's civilian requirements for maritime patrol, and make recommendations on how they can best be met (Cabinet referred particularly to eight areas: fisheries, resource management, conservation, pollution, immigration, customs, maritime safety, and search and rescue), and;

2. examine, in the light of the Defence Policy Framework,[29] whether a military maritime patrol capability should be maintained.[30]

It would be no exaggeration to state that with the then impending demise of the Air Combat Force, the entire future of the RNZAF as a military force was dependent on this report. And while history records that the maritime patrol capability was retained, the report was scathing of the state of maritime surveillance in New Zealand and especially so of aerial surveillance, remarking that operations in support of 'customs and fisheries are patchy, poorly co-ordinated, and occurring too infrequently and that 'New Zealand...does not have the necessary air surveillance capabilities to meet... civilian needs'.[31] The review concluded that a tenfold increase in aerial patrol activity was required to meet the civilian surveillance and deterrence effort. The greatest need was identified as being in support of MFish (now referred to as Fisheries under the MPI umbrella) and Customs, where it was estimated that up to 3000 hours per year of aerial patrol were required.[32] The report stated that each P-3 typically flew around 40 hours per year on civil patrol tasks, for a total of around 250 hours. Regardless of the perceived uncertainty over the future of the P-3, the committee recognised that as capable as the P-3 was, it was not an ideal surveillance platform for all circumstances. The areas to be patrolled ranged from coastline and territorial seas to the outer fringes of the EEZ and beyond into the South Pacific and Southern Oceans. While the P-3 was the aircraft of choice at the outer limits, it was a case of inefficient use of a strategic and expensive resource in the short/medium range environment – in what was a law enforcement role, where a small- or medium-sized aircraft could operate for around 12-15 per cent of the cost.[33] Clearly, a layered approach was required for maximum efficiency and the committee accordingly recommended that provision be made for a short-to -medium range patrol aircraft, or what later came to be known as the short- to medium-range maritime patrol

28 Department of the Prime Minister and Cabinet, *Maritime Patrol Review.*
29 Ministry of Defence (NZ), *The Government's Defence Policy Framework 2000.*
30 *Maritime Patrol Review 2001*, 1.
31 *Maritime Patrol Review 2001*, 35.
32 Ibid, 36.
33 Ibid, 27.

(SMRMP)[34] aircraft – to complement the P-3 – and be operated either by the RNZAF or by civilians contracted to the proposed Maritime Coordination Centre (now known as the National Maritime Coordination Centre or NMCC).

THE MARITIME FORCES REVIEW

The Maritime Forces Review: Key Findings (MFR), released by the MoD in January 2002, confirmed the dismal picture painted by the MPR in regard to the state of maritime surveillance in New Zealand. The review acknowledged the need for increased maritime surveillance in conjunction with maritime air patrol assets, and stated that the Navy were not configured for this work.[35] The review remarked on the complementary air and sea requirements for effective maritime surveillance and policing, noting that aircraft were the most cost-effective method of providing surveillance over a large area. The review also affirmed that surface vessels were required for presence, pursuit, arrest, and detention.[36] In other words, the surface patrol vessels are the maritime equivalent of 'boots on the ground'. The MFR surveyed the specific surface patrol requirements of the Ministry of Fisheries (MFish), the New Zealand Customs Service, the Maritime Safety Authority (MSA), the Police, the Ministry of Foreign Affairs and Trade (MFAT), the Department of Conservation (DoC), and the Ministry of Agriculture and Forestry (MAF).[37] The somewhat daunting conclusion was that 950 sea-days were required annually to perform inshore patrolling tasks (out to 24 nautical miles from shore),[38] and another 420 days were required for the offshore patrol tasks (out to the limits of the EEZ).[39] [40] To meet these tasks, it was suggested that a force of five smaller inshore patrol vessels (IPV), three larger offshore patrol vessels (OPV), and a multi-role-vessel (MRV) would be required.[41] The MRV would also be required to carry out the tactical sealift role throughout the South Pacific. The NZDF's draft Long Term Development Plan (LTDP) included provision of $500 million for capital acquisition to meet this requirement.

In summary, what the MFR did, among other things, was to determine the nature and scope of surface maritime surveillance requirements. It determined the civilian requirements for coastal and mid-range offshore capabilities, amounting to an annual 1370 sea-days of programmed and response activity.[42] It also reiterated New Zealand's responsibilities and obligations in respect to the Southern Ocean and Ross Dependency under the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). CCAMLR aims to ensure that fisheries do not develop at a rate faster than data can be acquired, to determine sustainable catch levels.[43] Further, the Review determined that a Naval Patrol Force (NPF) was necessary to conduct maritime surveillance, in conjunction with maritime patrol air assets, in the New Zealand EEZ and Southern Ocean and also to assist South Pacific island states to patrol their EEZs. The review's terms of reference required examination of the surface fleet's capability to interact with maritime aircraft. However, apart from a brief mention of the planned upgrade of the P-3's systems and the SMRMP study, there was nothing of substance that addressed the issue. Given the low levels of aerial surveillance at the time (around 250-300 hours per year) and the acknowledged enabling role of aircraft, this was surprising. It would not have been unreasonable for the MFR to suggest the significant opportunities for improvement in this area. It did however, reiterate that surveillance tasks are primarily non-military in support of civilian agencies. These tasks were grouped as: inshore out to 24 nautical miles; offshore to the limits of the EEZ; and tasks in the South Pacific and Southern Ocean.[44] Having established fleet requirements, in mid-2004 a further study was undertaken in conjunction with the civilian agencies to decide the number of vessels and fleet mix necessary. On 29 July 2004, the Minister of Defence signed a contract with Australian firm Tenix Defence Pty Ltd to supply the RNZN with a multi-role vessel, two offshore patrol vessels, and four inshore patrol vessels, under Project Protector. Delivery was to be completed by October 2007. No mention was made of the SMRMP. While these vessels were intended to fill the gaps in surface maritime surveillance, it would still be under the disadvantage of only being provided with limited aerial support. The enabling role that maritime surveillance aircraft play in supporting surface patrol assets is well acknowledged. They can cover much greater areas over a shorter period of time, being able to quickly gain a picture of events and identify targets of interest. This information can then be passed on to surface assets acting as intelligence-led response units to further investigate any suspicious activity and take action as required. It appeared that this effect was what was desired in the maritime domain, when a report was commissioned with the Defence Technology Agency (DTA) to provide options for providing a short-medium range aerial maritime surveillance capability.[45] The report was released in September 2004. However, no follow-up was initiated. The MPR had also recommended that, should the government decide to retain the RNZAF's P-3s, they should be upgraded with surveillance equipment that was suited for use in supporting civilian agencies engaged in the maritime security of the EEZ. At the time, it was suggested that each aircraft could be upgraded with 'good quality commercial off-the-shelf' equipment for a cost of approximately $10-12 million, or $60-70m for the fleet. The MPR made it clear at the time that one of the major reasons for retaining the P-3s was for their potential utility in supporting civilian agencies with maritime surveillance of the EEZ. However, it was subsequently announced that in October 2004, a contract had been awarded to L-3 Communications Integrated Systems for the P-3s to have a systems upgrade at a cost of $374 million for the fleet. Significantly, new ASW and ASuW weapons systems for the P-3s were not part of the package.

34 Which quickly evolved into the colloquialism 'shrimp'. It was also referred to as a short to medium aerial patrol capability. SMRMP is the preferred term in this essay.
35 *Maritime Patrol Review 2001*, 6.
36 Ibid.
37 The MSA are now known as Maritime New Zealand (MNZ), and fisheries and forestry come under the MPI umbrella.
38 By United Nations convention, the boundary of oceanic territory/EEZs is expressed in nautical miles.
39 *Maritime Patrol Review 2001*, 6.
40 The actual figures achieved were significantly less than this, refer to: Oliver, *Could UAVs Improve New Zealand's Maritime Security?*
41 *Maritime Patrol Review 2001*, 7.
42 Ibid, 20.
43 New Zealand Foreign Affairs and Trade, "The Antarctic Treaty System."
44 *Maritime Patrol Review 2001*, 4.
45 Galligan, *Meeting the Whole of Government Short to Medium Range Maritime Aerial Surveillance Requirement*, Defence Technology Agency.

SO, WHAT HAPPENED TO SMRMP?

The 2006 LTDP noted that the P-3 systems upgrade – which was underway by then – was 'central to meeting a broad range of civilian roles and tasks and for many functions required of the NZDF...', and that 'The P-3 undertakes surveillance of New Zealand's EEZ and the Southern Ocean, meeting our South Pacific search and rescue obligations and provides surveillance assistance to South Pacific nations. The P-3 has a high utility for a wide range of civilian and military operations.' Without the upgrade, it was suggested '...there could be policy failure in not meeting the objectives for EEZ and Southern Ocean surveillance and assisting South Pacific countries with surveillance of their EEZs.' There clearly seemed to be an increased emphasis on the civilian/all of government roles, with military duties almost added as an afterthought – this would fit with the government's thinking at the time, where it sought maximum utility of the NZDF's resources to the benefit of all of New Zealand, perhaps as a way of justifying expenditure. As a contrast, the Australian government long ago divested the RAAF maritime patrol fleet of principal responsibility for surveillance of its EEZ, as well as search and rescue, to allow it to focus on military roles. Cobham Aviation Services are contracted to provide both these functions for the Australian Border Force. This could provide a model for a similar organisation in New Zealand.
An emphasis on civilian roles coincides with an apparent downgrading of the SMRMP to a category termed as, 'projects that have benefit *but* are less critical to achieving policy objectives'.[46]

Subsequently between the 2006 LTDP and the September 2008 LTDP update, the SMRMP aircraft quietly disappeared from government defence documents.

So why did this happen? There are perhaps two reasons. Firstly, it is possible that any funds earmarked for use in obtaining a SMRMP capability were absorbed by the P-3 upgrade, which ended up costing more than five times the original estimate in the MPR. It is also unlikely that the RNZAF would have supported the acquisition of an SMRMP capability if it meant compromising the P-3 upgrade. Secondly, the RNZAF might have been reluctant to fully engage with the idea of an operational unit that has no warfighting function – in a similar manner to the Navy with its IPVs – and would have been wary of becoming the aerial arm of a coast guard type service. As a consequence of the demise of the SMRMP, aerial maritime surveillance remains at a similar level to that at the time the MPR was released. Successive governments have shown little interest in addressing this situation. This appears to be at variance with current government documents, which declare that protection of the sovereignty of New Zealand and its EEZ as paramount. While the P-3s carry out what is required of them in this area – and what they are funded for – a great deal of the P-3's time has been spent further afield engaged in activities in support of MFAT and also maintaining currency in warfighting skills, such as ASW training. This is unlikely to change over the next few years with the arrival of the P-8 (as previously discussed) and as the Orion is withdrawn from service.

The gaps in maritime surveillance, therefore, continue to exist, and it is a matter of how much longer the country can afford to ignore it. There is still a compelling case to increase maritime surveillance as stated in the MPR nearly 20 years ago and, since then, the additional spectre of trans-national terrorism has been added to go along with Customs' regular concerns of illicit movement of drugs, people and contraband in general. This has been reiterated in subsequent Ministry of Defence documents. The 2010 *Defence White Paper* stated that 'non-defence maritime patrol requirements cannot currently be met by the NZDF', noting that 'a review study in 2009 indicated a shortfall in the number of annual P-3 Orion flying hours available for effective aerial surveillance of the EEZ...'.

46 Ministry of Defence (NZ). *Defence Long-Term Development Plan*, 54 – Author's emphasis.

AN ITALIAN AIR FORCE ATR-72 MPA.

Further noting 'a number of low-end regional surveillance tasks (for both defence and other agencies) could be performed more cost-effectively by using maritime patrol aircraft with short take-off and landing and sufficient range.[47] The introduction of this capability would increase New Zealand's surveillance capacity in both the EEZ and the South Pacific'. Continuing on with the previous government's expectation of maximum utility of defence equipment, it suggested that 'to maximise its cost-effectiveness, this new aircraft would also be expected to perform a transport and multi-engine flying training and consolidation function, as currently provided by the B200 King Air. An indicative business case is being prepared, with the intention of acquiring this new capability as soon as practicable'.[48] This is explicit in that a defence solution was proposed for a non-defence task, with the implication that the NZDF would carry the costs of providing services for other government departments. Once again, nothing happened, and again it quietly disappeared off the radar. The requirement once again appeared in the 2016 *Defence White Paper*, though in very brief form. Having noted as previous, 'The increasing number, range and sophistication of actors...are generating corresponding increases in demand for maritime surveillance'. This was to be provided for with 'enhanced air surveillance capability to cope with increased surveillance demand within New Zealand's maritime domain'.[49]

While nothing happened immediately, what did happen was that the RNZAF obtained replacements for its ageing King Air B200s. Four low airframe hour King Air B350s entered service during late 2018 and early 2019. One of the reasons why a larger aircraft was obtained was to accommodate Air Warfare Officer training, which has now been repatriated from Australia; the bigger B350 being able to fit suitable consoles and equipment in the cabin for practical training. Two of the aircraft will be permanently fitted with a sensor suite in a canoe fairing under the fuselage that consists of electro-optic and infrared cameras and, a single array multi-mode surveillance radar. The sensor suite is utilised for sensor operator training, and while training will be the ultimate focus of the fleet, there are some obvious synergies with operations. While some of the sensor training is likely to be synthetic in the context of warfighting, the more general aspects of airborne maritime surveillance can be carried out live around the coast of New Zealand. 'Train as you operate' is a maxim we often hear, but rarely have the opportunity to do. It would appear that the opportunity to fulfil training requirements, while also fulfilling commitments to the surveillance of New Zealand's EEZ, is a win-win situation should it evolve that way. One might expect that the modified aircraft (with perhaps four people on board) would have an endurance of up to five hours, [50] which is useful in the context of EEZ surveillance and could operate out of all the regional airports. This is incidental, however, and by no means a solution.

Just as the SMRMP slowly faded between the 2001 MPR and the 2008 LTDP, history seemed to repeat itself when, between the 2010 DWP and the Strategic Defence Policy Statement 2018,[51] there was no mention of a medium-range airborne maritime surveillance aircraft. However, when the government gave approval to purchase the P-8 in July 2018, it noted that a complementary air surveillance capability might be necessary and that further analysis was required. It also noted that the minister would report back to Cabinet on the available options, probably through the next DCP.[52] The cabinet paper also noted that the B350s would be able to carry out 'basic in-shore surveillance'. The government press release, a week after Cabinet approval, noted that the government would consider options for a complementary maritime surveillance capability for 'tasks within New Zealand's EEZ and near region'. The SDPS – released in the same month – made no mention of a complementary air surveillance capability. At the New Zealand Defence Industry Association Forum, held in November 2018, the broad requirements of the project, now referred to as the Air Surveillance Complementary Capability (ASCC), were given by the Ministry of Defence and other potential users.[53] However, with the release of the DCP 2019, it was called the Enhanced Maritime Awareness Capability, or EMAC, as it is still referred to at the time of writing.

SO WHAT NEXT?

Throughout the COVID-19 crisis, the government was generating money through quantative easing [54] and loans in an effort to minimise the damage to the economy – though best predictions are still grim reading, with forecasts of up to 10% unemployment and a reduction of around 4% of GDP for 2020. The debt the government will carry for years to come will require a major realignment of economic policy, likely not to be revealed in detail until post-election 2020, though New Zealand is better placed than many countries to recover, due to relatively low levels of debt leading up to the crisis. There will possibly be a significant increase in spending in some areas, such as major infrastructure projects, in an attempt to stimulate the economy and reduce unemployment. There will also have to be a concomitant reduction in spending in other areas to fund these major projects. One area that may see frozen, if not reduced, spending could be Defence. That being the case, EMAC might be one of the first projects deferred, if not cancelled altogether. However, with the possibility that exports and overseas spending generally may be affected once governments take stock of their economic situation – plus ongoing global issues with the imposition of punitive tariffs and sanctions – economic focus could perhaps shift to domestic consumption until export markets reset. Some nations may feel less inclined to renew costly fishing quota licences or may knowingly exceed quotas. We may also see an increase in the movement of illicit goods. Surveillance of New Zealand's fishing grounds and EEZ remains marginal, and this could see foreign fishing

47 The short take off and landing reference is curious. It might be presumed that it is implying an ability to operate from regional airports around New Zealand, such as Whangarei, Gisborne and Dunedin, for example, as well as around the South Pacific.
48 Ministry of Defence (NZ), *Defence White Paper 2010*.
49 Ministry of Defence (NZ), *Defence White Paper 2016*.
50 New Zealand Defence Force, "Capability: King Air 350."
51 Which for all intents and purposes was the Coalition Government's DWP albeit with virtually no detail.
52 Expenditure Review Committee. Cabinet paper, *CAB-18-MIN-0305*.
53 Campbell, "New Zealand's Maritime Border: An Opportunity for Industry." *Line of Defence*, Issue 12, Autumn, 2019.
54 Where central banks increase the supply of money by buying government bonds and other securities.

THE RNZAF'S KING AIR B350S ARE PRIMARILY USED FOR TRAINING PURPOSES AND THUS HAVE LIMITED CAPACITY FOR MARITIME SURVEILLANCE. IMAGE COURTESY OF JORDAN WILLIAMS.

vessels trying to take advantage of this during a time of uncertainty. There is, therefore, an argument to put to government that EMAC is a gap in capability that should be closed as soon as possible.

Given the range of possibilities as noted in the DCP 2019, i.e. manned aircraft, UAVs, and satellites, this may indicate that over the long-term, a layered approach that utilises all available capabilities is preferred. While this may represent the gold-plated and thus the most costly solution, it is the only one that will provide the persistence necessary to effectively deter illegal activity; random or episodic engagement will only provide random or episodic effect. The use of satellites and UAVs in other employment contexts is also stated as a medium-long term goal. With regards to UAVs, there is reference to acquiring a long-endurance UAV to support land and maritime forces, with an investment decision after 2030. There is also reference to a tactical remotely-piloted aircraft for use in the maritime, littoral, and land environments, with an indicative IIS of 2025. So it appears that, over a decade or so, the NZDF could introduce up to three types of unmanned aircraft systems (UAS) into service; a maritime surveillance system after 2023, devoted to supporting all of government maritime security; a small tactical system around 2025 in support of military operations; and finally, a long-endurance strategic system after 2030, primarily in support of military operations. This is a major commitment – or at least an aspiration – to an entirely new type of platform and is quite ambitious, given the NZDF has only limited experience with UAS and currently has no operational unmanned systems. With the P-8 and the C-130J being introduced at around the same time – i.e. from 2023 onwards – this will present challenges of resourcing and capacity. Though, over the longer-term, there may be synergies to be exploited that will allow rationalisation of the unmanned fleet. UAVs have many advantages suited to the maritime surveillance role and represent state-of-the-art capability and probably the first choice as a long-term solution for airborne maritime ISR. Their persistence and inherent low observability would be highly desirable, and knowledge of the presence of such a capability in the EEZ of New Zealand and its territories would act as a deterrent to illegal activity. UAVs are, without doubt, the way of the future in maritime surveillance, but there is still considerable work to be done, particularly with regard to all-weather capability and integration into the national airspace. As such, they are unlikely as a short-term solution.

With regard to satellites, listed under Information Capability: Investment decisions planned for 2021, are set out in DCP 2019 'Maritime Satellite Surveillance' capabilities, with an indicative IIS of 2025. It appears this system will be acquired through existing satellite service providers and be available to all of government. This would seem to fulfil any satellite component of EMAC, both in function and area of operation. The two year difference in timeline for IIS of EMAC and a maritime satellite surveillance capability could simply indicate a phased introduction of capability, though there is no reason why commercial services could not be contracted from 2023, specifically to fulfil EMAC in the short-term, until a maritime satellite surveillance capability comes online. Given the complexities and cost of establishing sovereign satellite systems, it seems to be a signal that New Zealand will continue to engage third-party satellite services in the medium-term. It is, therefore, possible that the maritime satellite surveillance capability – which might best be considered as a discrete stand-alone project outside the scope of air surveillance – will fulfil the 'high ground' of the EMAC by default, and that satellites as a component of EMAC in the short-term may or may not materialise; leaving manned aircraft as the only realistic option.

CONCLUSION

It is a matter of public record that there are deficiencies in New Zealand's maritime domain awareness and, despite the best of intentions over the last 20 years or so, little progress has been made to address this situation. If six P-3 Orions have been unable to be resourced to meet the demand of all of government for maritime surveillance, four P-8 Poseidons are unlikely to meet the demand either. The P-8 is a high-end warfighting machine, whose main role will be blue water maritime patrol in support of cooperative efforts globally to maintain the integrity of international sea lines of communication, ensuring the free-flow of goods that New Zealand depends on for its economic well-being. One consequence of the virtual crash of the airline industry – due to COVID-19 – is a surplus of trained pilots (some of whom are ex-military) and indeed twin turboprop commuter aircraft. Some of these are suitable aircraft for modification to the maritime surveillance role; for instance, small numbers of both the ATR-72 and Dash 8 aircraft have been converted for maritime duties by various organisations overseas. As EMAC would represent a defacto coast guard, carrying out purely civilian tasks in support of all of government, there is no logical reason for EMAC to be either controlled or operated by the military.

As noted in the introduction, with the predicted increasing importance of the EEZ and the continental shelf as a source of wealth to the nation, and with possible increased external pressure on those resources in the future, it is appropriate that some form of action is taken to protect and enforce New Zealand's sovereign rights. Under the heading EMAC, three options have been presented in the Defence Capability Plan, either used in combination or standalone, and over a period of time. Any sovereign satellite capability is likely to be an all of government project, with the NZDF merely one user. The two remaining options of manned short-medium range patrol aircraft or UAVs (ultimately operated in a layered approach) both offer viable solutions. In the short-term, the former probably offers the best solution, as there are no barriers in place to their operations within the current CAA regulations, and they could be acquired and operational within a relatively short timeframe. However, for state-of-the-art capability, UAVs are the first choice as a longer-term solution. The introduction of such a capability would send a strong message to those who may challenge New Zealand's sovereignty; that New Zealand takes homeland security seriously and that the high chance of discovery and punishment makes it no longer worth the risk. However, that could be at least 10 years away, as could a sovereign New Zealand maritime satellite surveillance capability and, until that time, a manned platform appears to be the logical and probably the most cost-effective solution, just as it was 20 years ago when the SMRPA first came to light.

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ARTIFICIAL INTELLIGENCE AND THE FUTURE OF AIR POWER

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Professor Kainikara is a former fighter pilot of the Indian Air Force. During his service career, he flew nearly 4,000 hours on a number of front-line fighter aircraft, held various command and staff appointments, and is a recipient of the Air Force Cross. Sanu is currently the Air Power Strategist at the RAAF's Air Power Development Centre. He is an Adjunct Professor at the University of New South Wales and the inaugural Distinguished Fellow at the Institute for Regional Security. Professor Kainikara studied at the University of Madras and gained his PhD in International Politics at the University of Adelaide.

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FOREWORD

One of the greatest global challenges facing a stable rules-based order is the unprecedented and accelerating technology revolution, in particular, how it will affect the fragile institutions within states. This technology revolution, through the emerging use of artificial intelligence, is rapidly changing the way that states can and will employ air power to project their national power.

While automation and machine learning threatens other aspects of human endeavour, de-skilling human operators, and reducing the number and nature of jobs available, air power is likely to be an early and rapid adopter of artificial intelligence because it will allow quicker and safer decisions to be made.

Professor Kainikara has taken a unique approach using a technology acceptance curve to explain how rapidly artificial intelligence is changing air power technology. He also describes the human side, which has the potential to limit the acceptance of artificially intelligent systems. He then outlines a future model of air power where these intelligent systems have been adopted and proposes how the joint domain will be changed. This Working Paper, while focusing on artificial intelligence, does not omit the human condition – an essential element of air power. It outlines a case where artificial intelligence is inevitable and how we might need to adapt our own thinking to keep a competitive edge. I hope that the concepts outlined by Professor Kainikara will generate debate and encourage other authors to share their own research and ideas.

GPCAPT Andrew Gilbert
Director of the Air Power Centre
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INTRODUCTION

Artificial Intelligence (AI) is one of the latest technological marvels to have taken the fancy of futurists, strategists and technologists, and also captivated the world. It is also possibly the one with the greatest capacity to create change and cause disruption to the smooth and normal functioning of the world. Over the past few years, research breakthroughs and associated policy conversations have alerted and altered the public consciousness regarding the potential risks and benefits of AI. The discussions regarding AI – what it means, how it will affect human societies, and the consequences of keeping up with the ongoing developments as well as not keeping up with them – are issues that have agitated the minds of people across the world.

It is now certain that no human enterprise – warfare, healthcare, economy, art, education, and myriad others

– will be immune to the encroachment of AI. As and when AI is fully incorporated into the working of a society, the very roles of humans in that society as we currently understand it will change irrevocably. AI has been operationalised, but its maturity is at the basic level of the beginning of a long journey. With maturity, its impact on society will also increase manifold.

It is an old cliché that air power was born of and nurtured by technology, but it still holds as true today as it was at the birth of air power as the third element in traditional military power projection capabilities. Therefore, it is not surprising that AI, the latest technological development, will impinge on the generation, sustainment, and application of air power. The implications of the impact of AI on air power will perhaps be more significant than what can be conceived now. It will influence the breadth and depth of air power and alter the prevailing concepts regarding its conceptualisation, development, and delivery.

Under these circumstances, in the future, air power will be applied in significantly different ways than how it has been done in the past and how it is being done at present. However, predicting the future is not an accurate science, even if adequate information is available. The maximum 'throw-forward' in predictive forays that can be considered viable is only 20 years. Even though a 20-year window is a short span of time, a reasonably good effort can be made to look at the future by tracking the forward march from where air power has come from and where it is at today, and then extrapolating it to the future.

This paper will examine the impact of AI on the future employment of air power under five very broad groupings that will make it easier to understand the interaction of AI with air power and clearly delineate its impact on future air power applications. They are:

1. the major enduring aspects in the application of air power in order to fix a datum line from which it will become easier to discern the current status of air power and draw a line from where this point has been reached;
2. the intricacies of understanding the relationship between time and complexity of technology vis-à-vis the exponential technology acceptance curve in the generation of air power;
3. an understanding of AI as it pertains to military usage, with special reference to air power;
4. superimposition of AI onto air power as it is recognised today in order to make a few educated guesses regarding the uncertain futures that are being generated; and
5. an examination of how the induction of AI into an air force will affect the focal points of the air force.

ENDURING ASPECTS

Air power has been an instrument of war for a little over a century. In this developmental journey of a century, it has greatly enhanced its capacity to create the necessary effects through the application of lethal force on one end of the spectrum, to the delivery of humanitarian aid and disaster relief during calamities at the other. The instances of the employment of air power in different events are numerically very large. Each such episode has contributed to the refinement of the techniques of employment, created opportunities to develop improved concepts of operations, and broadened strategic air power thinking. In modern times, after the end of World War II, there have been unambiguous moments in the application of air power that have had durable effects on the development and concepts of air power, mostly at the operational level. However, in the strategic arena, Operation Desert Storm in 1991 stands out as a watershed moment in the employment of air power.

Operation Desert Storm demonstrated the great strides that air power had made in enhancing its effectiveness. More importantly, it demonstrated the agility with which air power's command and control structure could be integrated with broader campaign plans. Air power also validated its claim of being an element of military power that could create joint effects with minimal effort, but with rapidity, precision, proportionality, and discrimination. While air power has had its watershed moments during its century of development, 1991 was the year when the promises made by air power theorists of the early years were delivered in full, with the perceived limitations of air power as a combat element being removed and air power becoming vindicated.

From that unmatched demonstration of its capabilities, air power has rapidly improved its capacity for delivering the necessary lethal force with precision, proportion, and discrimination, while minimising both collateral damage and risk to own and friendly forces. The qualitative edge of air power has been enhanced in a process that could be termed an evolutionary revolution. While the decade that followed 1991 entrenched the enduring aspects at the root of air power as the basis for its application, it also had significant implications for its future.

A fundamental question emerges from the developments of the recent past – what is and will continue to be enduring in the application of air power? In other words, what aspects have not changed in the employment of air power over the past century of its existence as an instrument of military power, which are likely to persist into the foreseeable future?

The answer is two-pronged. First, the best practices in the application of air power, from the first days of its employment as a military capability, have always been captured by the practitioners as doctrine. The philosophical level doctrine of capable air forces has always been sophisticated and continually refined with new developments, either in the concepts of delivery or the technological innovations that improve air power capabilities. Second, the main enduring trend of air power is that the classic roles of air power will not change, even as their delivery, in terms of methodology and concepts of operation, will continually evolve. This aspect is of great importance in understanding the role AI is bound to play in the foreseeable future of air power development and employment.

The four fundamental roles of air power are control of the air, strike, air mobility and intelligence, surveillance and reconnaissance (ISR). Control of the air continues to be a prerequisite for the success of all military operations. This was recognised almost simultaneously to air power becoming an influential element of military power at the beginning of World War II. Airborne strike has now become accurate, proportionate, and discriminate facilitated by technology-enabled capabilities and weapon systems, as well as a systems approach to targeting. It has also become time-sensitive through the use of uninhabited combat aerial vehicles (UCAV) that can fly at very high altitudes and have long endurance, making it possible for it to remain 'hidden' from potential adversaries until the time the target has been identified and a strike can be carried out.

Air mobility has developed into a capability that is increasingly responsive and able to sustain large forces operating further away from home bases. The ability to transport personnel and materiel to the operational theatre and sustain them in the war zone has been enhanced with enhancements in the range, speed, and carrying capacity of transport aircraft. Further, air mobility is critical to Special Forces operations. In a majority of cases, Special Forces are inserted, sustained, and extracted by the use of airlift assets, and they are provided fire support by the strike elements of the air force. Airborne ISR envelopes the battle space and facilitates information flow across the chain of command, domains and time.

These basics of air power are enduring. The trend in air power development since the mid-1990s has been to make these roles more effective through the innovative absorption of technology that, in turn, improves the responsiveness and efficiency of the decision-making process that delivers the appropriate effect. For example, the enhanced range of air-to-air weapons and increasing sensor ranges has resulted in an expansion of the diameter of the air superiority bubble that can be created. Similarly, the improvements in response time and accuracy of strikes as well as the limited autonomy that has been granted to them make air-strikes a prized capability, capable of creating the necessary effects when they are employed, in the majority of cases. Air mobility has also been enhanced with much greater one-time load capability that is delivered faster. ISR has seen sensor horizons move farther away, become more discerning and also become space-based.

Essentially air power as an entity has become more responsive and accurate while being able to influence a much larger 'area' than ever before. It can protect more, see further, be more covert, and reach out to touch more targets, faster.

THE PLATEAUING OF AIR POWER DEVELOPMENT

The improvements that have been brought about in the conduct of the enduring roles of air power have improved the efficacy of its application. However, the reality is that the technology-enabled evolution that air power has been undergoing for the past century has plateaued. Air power itself has now matured into an important and critical instrument of national power. There is no doubt that improvements in the application of air power and the methodology of the conduct of its core roles will continue to improve. Targets will be struck with greater accuracy, response times for strikes will reduce and collateral damage will become miniscule. The cycle of finding, fixing, tracking, and engaging a target – the ability of a system to perform a mission – will become combined in a single platform, with or without a human onboard will become the norm rather than the exception. Such a system will increase the reliability and decrease the time for response. Such enhancements will continue, perhaps at a slower pace than before.

The rate of introduction and the assimilation of new technologies into air power employment, as well as the development of new concepts for their application, has increased many-fold in the past few decades. The impetus for pursuing the development of new and innovative aviation-related technologies and the inordinately rapid rate of their induction could be the need to support a single operator carrying out increasingly complex multi-tasks in an air power context, as opposed to other military capabilities that are normally carried out by a group of people. From being technology-enabled, air power has become technology-integrated.

There are three enduring factors that have become entrenched as determinants in the employment of air power, even as its vigorous development of the past century is plateauing. First, the strategic need for strategic power projection, which has become critical to ensuring national security, has become the realm of air power. Second, in the application of air power, precision has replaced mass. Third, at the operational level, air power has now matured to an extent that it can create the desired effect with extremely minimised collateral damage. All three determinants are crucial to the design of air power for the prosecution of a conflict within the norms accepted by contemporary nation-states in the conduct of a modern war. Currently, air power is continuing to accept new technologies, but they only further entrench and enhance the enduring factors that have been described above. They do not create a quantum jump in air power capability.

THE TECHNOLOGY ACCEPTANCE CURVE (TAC)

The graph in Figure 1 plots relative time on the X-axis and the complexity of the technology to be accepted on the Y-axis. The Technology Acceptance Curve (TAC) that has been plotted illustrates the exponential, rather than evolutionary growth and development of technology in terms of the complexity and sophistication associated with it. On the TAC has been superimposed five technological innovations that have created, or will create, a step-change function in the century-old evolution and application of air power. Here, a step-change function is described as a change that creates highly significant and extraordinary improvement in the efficacy of air power that stands outside a normal evolutionary curve.

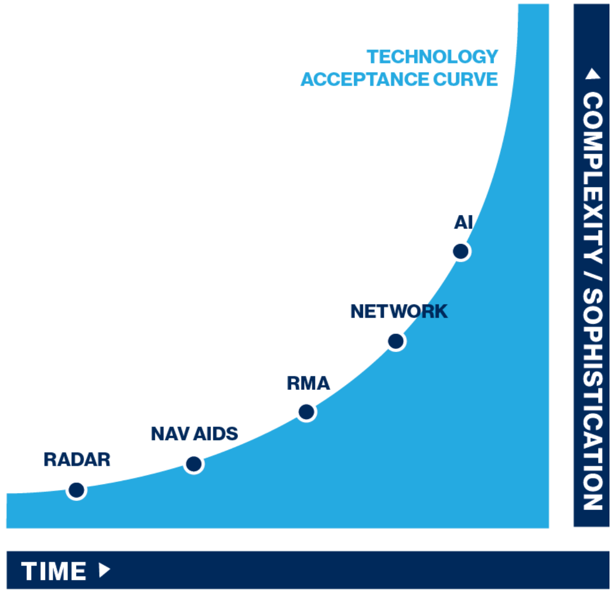

FIGURE 1

STEP CHANGES IN AIR POWER DEVELOPMENT FACILITATED BY TECHNOLOGY

The first four of the five step-change functions have already taken place. The fifth, AI, is already on the horizon, even though its acceptance and operationalisation within the ambit of air power is still some way in the future. There are two factors that must be highlighted in Figure 1. First is that in the earlier step-change functions, such as radar and navigational aids, the complexity increase of the technology was relatively small, and the time available to accept the technology was comparatively long. Therefore, even though both of these developments were step-change functions, their absorption into air power was relatively easy to carry out – smaller capability jumps and sufficient time to adjust to the changes. As the complexity and sophistication of the technology being offered increase, such as for the Revolution in Military Affairs and Networking, the time available to accept the technology reduces primarily because the TAC develops an exponential change.

Two fundamental factors become apparent from the TAC. First, the complexity of technology to be absorbed is continually increasing and second, that the time available to accept and operationalise cutting-edge technology is continually decreasing. This process will continue till such time as it reaches a saturation point and no more efficiencies can be produced. It will rest at that point till such time as when another, as yet unknown, factor will create further efficiencies. The TAC can be smoothed out to cater for the lethargies inherent within a force that also wants to accept the technological developments that are taking place. Smoothing the TAC, as shown in Figure 2, will create more time for the acceptance of the new technology. However, there is a fundamental challenge that comes with smoothing the TAC – the complexity graph will increase exponentially, and catching up with the sophistication of technology will become extremely difficult and resource-intensive. In a worst-case scenario, the technology being absorbed will not be at the same level of complexity as what is made available to forces able to stay on the original TAC, creating an unbridgeable technology gap.

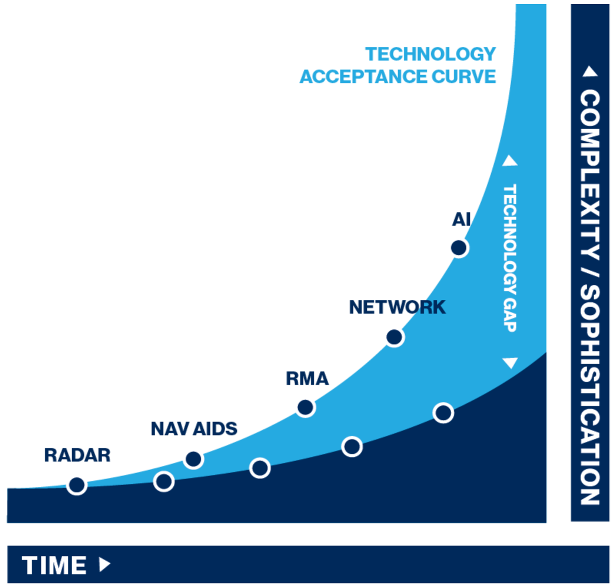

FIGURE 2

THE NEXT STEP-CHANGE FUNCTION ON THE TAC

It can be stated with reasonable certainty that the next step-change function to impact air power development will be AI. In assessing this evolution, the semi-autonomous and intelligent uninhabited aerial vehicles (UAVs) and their armed versions, UCAVs have been discounted as having created step-change functions. Their influence on the development and application of air power has been evolutionary rather than revolutionary. However, when UCAVs are combined efficiently with AI to create a 'system of systems', resident in the same platform, a step-change in air power capabilities will become tangibly visible. Such a system may not be fully autonomous and could have a human-out-of-the-loop to provide strategic governance.

ARTIFICIAL INTELLIGENCE

WHAT IS AI?

AI is being developed for use in almost all areas of human endeavour, including the military forces. Perhaps because of this widespread utilisation, defining AI is considered a difficult task. AI is far too nuanced to be placed under one generic definition and needs to be described in a contextual manner. This fact is further reinforced by the very broad spectrum of AI that starts from a binary trip-switch to self-learning and truly intelligent machines. A broad and base level definition of AI could be 'the ability of a machine to scan, analyse, and translate information to achieve the desired outcome'.

This fundamental definition can then be altered to encompass the nuances of AI as it is used in different spheres. Building on the base definition, for the military the definition can be further distilled to read as, 'intelligence introduced into a warfighting system, which provides that system with the ability to function with varying levels of autonomy and achieve a desired outcome without any human inputs for the full span of an independent mission.' This is the definition that has been used for the discussions in this paper. Drawing a baseline is critical to understanding the future. To understand the future utilisation of AI requires a clear position statement regarding what is meant by AI. This paper examines three aspects of importance regarding the influence of AI on air power:

1. the employment of AI in the application of air power;

2. the potential of AI to revolutionise the employment of air power; and

3. the impact of AI on the four focal points of an air force.

CHALLENGES TO THE EMPLOYMENT OF AI

The current methodology for the application of air power normally entails the employment of airborne systems. UCAVs are already in regular use, but function with a 'human-in-the-loop' – with the person remotely located in the majority of cases. The most important factor about the employment of UCAVs is that the weapon release decision is always taken by a human being since it is still not politically acceptable for destructive power to be employed by AI in an autonomous mode. Further, there is also a governance requirement to ensure that weapons must only be employed in accordance with the Laws of Armed Conflict (LOAC). This could be better accomplished with a human in the decision-making cycle for weapon release. The UCAV System could be considered the halfway point in the continuum of air power development. It fits between traditional strikes by inhabited aerial platforms and the concept of complete autonomy for the system, including the weapon-release decision.

It is now technologically feasible to have complete autonomy for airborne systems to carry out an entire independent mission without having even a human-out-of-the-loop for governance purposes. Such systems have been conclusively demonstrated and are real. It can also be stated with more than an adequate assurance that the introduction of AI into the human decision-making cycle will take place in the not too distant future. However, few challenges still remain that will impede further progress in providing full autonomy to the systems that are operated by AI. These challenges would have to be overcome decisively to ensure further progress in the acceptance of AI-controlled systems.

These challenges are not technological, but sociological; derived from the cognitive domain of human-beings. Four interconnected human factors inhibit absolute acceptance of AI and the transfer of complete autonomy to AI operated systems: **trust, inertia, understanding** and **empathy**. Trust – the reliance on the integrity of a person, or on some quality or attribute of a thing – is the biggest challenge that AI faces in gaining acceptance within human thinking. There is an inherent and palpable mistrust of machines in the human mind, which takes a conscious effort to overcome. Inertia, both personal and organisational – the tendency to be inactive, resist change, or continue to travel in a straight line – adds to this mistrust, further entrenching the tendency to resist change. Equally important is the lack of clear understanding of the intricate decision-making process of AI that in turn creates apprehension in delegating complete autonomy to an AI-operated system. The apprehension peaks when the delegation relates to the most critical phase of decision-making – that of weapon release. The fourth issue is empathy – the mental acceptance of the feeling or spirit of a person or thing – or the lack thereof. The inherent human need to be in control of machines – brought about through generations of human-machine interactions, with the humans being in control – creates a lack of empathy. Further lack of empathy for AI is also caused because of its dissimilarity to human beings. This human tendency is also difficult to overcome and will perhaps take time to be accepted.

AI AND AIR POWER – A FUTURE MODEL

As AI starts to become more 'acceptable' within the decision-making cycle of airborne systems, it is necessary to examine the probable changes that could take place in the employment of air power in the future. In the immediate to near-term future – within about 15 years from the time AI is fully accepted into the 'observe, orient, decide, act' loop in the application of air power – the following four major changes are likely to take place.

Human-Machine Integration. First, air power will be delivered, across all its roles, through human-machine integrated mission packages. A human-machine integrated package would mean that some elements within the package would be AI-operated systems with autonomous liberty while others will be systems, inhabited or otherwise, but with a 'human-in-the-loop'. The level of autonomy given to the AI-operated systems would vary with the numbers involved and also the level of acceptance of AI prevalent at that time. In a human-machine integrated package, there could also be a governance role for the inhabited systems that could be tailored to meet mission specifications.

Target Recognition and Targeting. Second, will be the acceptance of autonomous target recognition, selection and engagement. The application of air power is controlled directly by the find, fix, track, target, engage and assess (F2T2EA) process. This engagement process to create the necessary effects will be AI-controlled and, therefore, be a more rapid process once sufficient autonomy is built in. The F2T2EA process will not only become an accelerated process but will also become more accurate, especially in the phases of engaging and assessing.

Airspace Management. Third, autonomous airspace management could be done through the employment of AI. Autonomous airspace management will facilitate a seamless interface of separate civil and military airspace as well as the control mechanisms. In this context, there is one element that needs further elucidation. In the airspace management regime, it is possible that in the near future, autonomous aerial vehicles will be controlled by autonomous airspace management agents. From a purely human understanding and point of view, such a situation – of machines controlling machines without direct human oversight – may not be an acceptable state of affairs. Perhaps, at least for the present, this would be a 'bridge too far' in terms of the acceptance of, and trust in, autonomy.

Combat Search and Rescue Operations. The fourth change – one that could be embraced as an earlier change that could be facilitated by the induction of AI into operations – is the benign role of CSR. The advantage of employing AI to conduct this critical role, especially in times of hostilities, is that one's own combatants are not placed at risk in attempting the rescue of injured or other combatants in trouble. The employment would be somewhat like the SEAD missions that uninhabited aerial vehicles undertake on the first day of a campaign. Uninhabited AI controlled aerial vehicles could be the answer to complex CSR missions.

REVOLUTIONISING THE EMPLOYMENT OF AIR POWER

The employment of AI and autonomous systems in a normal day-to-day scenario is unlikely unless a number of pertinent questions have been answered fully. Truly autonomous operations will become a reality only if two fundamental questions can be answered in the negative: one, is there a role for humans in the system while a mission is in progress? Two, should a human be in the decision-making loop to exercise a veto function, which would amount to governance oversight in design and operations? If the answers to the above most fundamental questions are positive, then it is certain that these operations are not autonomous in the strictest sense of its definition. Another challenge that slows the process of accepting autonomous operations is the reluctance of the political and military leadership to accept the efficacy of AI to conduct such operations. Only when the human reluctance to implicitly trust AI and a system of uninhabited combat air vehicle AI are completely removed from the cognitive domain of strategic decision-makers will real autonomy be granted to these systems. When the UCAV-AI combined system is accepted as the normal way of conducting operations without any external human interference, then three basic aspects of warfighting will change. The conduct and characteristics of war, the philosophical level doctrine and strategy for the employment of air power, and – at the operational level – concepts of operations will have to be revised. These changes will, in turn, impinge on all other aspects of war and conflict.

Conduct and Characteristics of War.
When autonomous systems fighting each other become the norm, the conduct and characteristics of war will obviously change. The first question that emanates is whether or not the contest between two machines could be classified as 'war' in the conventional sense of the word. If war was to be fought only between two machines, then there would not be much urgency to create rules and laws that govern its conduct; nor would there be a great deal of interest in studying its characteristics, other than in a purely technical sense. However, it is highly unlikely – at least in the near to mid-term future – that a war would be fought only between machines; a future war would invariably involve a combination of machines and humans. In such a situation, the conduct and characteristics of war would change dramatically, along with the need to review the extant rules and laws that govern the conduct of war. A number of issues will come to the fore. For example, would it be legal and/or ethical for a machine to kill a human-being and for a human to destroy a machine? Would it be permissible for a machine to neutralise a human-inhabited decision-making centre if that had been identified as a centre of gravity? While it is not possible to predict the direction of the changes that will take place, the certainty is that the conduct and characteristics of war will change and become more complex.

Philosophical Doctrine and Strategy. Philosophical doctrine underpins all aspects of the employment of air power. Currently there is no air force that has factored in the attributes of AI into the development of its capstone doctrine. Although it is accepted – for the time being – that AI has not come of age, air forces of calibre need to start analysing and investigating the fundamental changes that have to be made in their doctrine to accommodate the altered capabilities that will come with the advent of AI. If such an initiative is delayed, air forces risk having to play doctrinal catch up in the long term. Changes to philosophical doctrine will also have cascading effects, necessitating immediate and long-term alteration of force structure, capability development processes and the conduct of the raise, train, and sustain functions of a force.

Concepts of Operations. It is at the operational level that the induction of AI will create the maximum visible effect. The fundamentals of developing concepts of operations will remain the same: concepts for the employment of forces at the operational level must always be aligned with the inherent necessity to create strategic effects, which in turn must support the achievement of national objectives. As and when the employment of AI becomes an overt reality, it will form the nucleus of the concept and will greatly increase the complexity of operational level conceptual development. At the same time, on-going developments in AI will limit the timeframe within which a particular concept of operation would be viable before becoming redundant. Since the same situation would be applicable to a potential adversary, the uncertainties in the conduct of war will increase exponentially. Success in operations will obviously hinge on the force being extremely agile, both conceptually and physically.

AREAS OF RADICAL CHANGE

Based on the assumption that autonomy will become a reality in the future, not too far away, and a routine feature of air operations, four areas of air operations that will see radical changes can be identified. They are:

1. Air campaign planning: the limits of human creativity could be augmented to increase the options and speed of air campaign planning.
2. Air domain: with the advent of systems controlled by AI, the air battlespace could be fully dehumanised, devoid of any physical human presence.
3. Air power application: the application of air power will, in the future, be a contextually balanced combination of mass and precision.
4. Domain boundaries: the boundaries that clearly define the physical domains will start to become blurred and over a period of time become indistinguishable from each other, which could lead to multi-domain operations becoming the norm.

The impact of AI will be felt in all aspects of air power, from its conceptualisation, generation, application, and sustainment. Its influence will invariably straddle the full spread of activities from the strategic to the tactical. Since there are already sizeable air power components resident in both the land and maritime forces, it is not difficult to perceive that the application of air power will no longer be the sole realm of an air force. Although the physical demarcations between the domain-centric forces may have blurred, the warfighting domains are still clearly defined by the domain knowledge and professional mastery of the soldiers, sailors, and airmen. With the unlimited introduction of AI, the specialist knowledge required to employ systems will also have a common element to it, which in turn will further distort the clear definition of domain-centric mastery. The employment of AI will smudge the traditional divisions between the physical warfighting domains and blur the traditional divisions of responsibilities and liabilities.

IMPACT OF AI

Air power has, in the past few decades, become a capability that has reached a point from which all further improvements will only be incremental in a contextual manner. Step-change functions that have added to the rapidity of air power development are unlikely in the current developmental situation. Air power delivered by a system that combines AI and machines is clearly the future. Even if complete autonomy remains a futuristic concept, there is a certain assurance that fully autonomous systems in the warfighting arena will become reality. The AI-machine combination functioning completely autonomously will be the next step-change function in the developmental history of air power. This will provide an exponential improvement in the application of air power that will elevate air power itself to the next level of competence. Since the improvements will emanate for the strategic level, it is not difficult to imagine the cascading effect the changes will have in the conduct of an air campaign and the tactical appreciation of operations.

One of the most important impacts would be the difficulty in understanding the AI characteristics of the adversary. Although AI is 'machine' built, its development will also be directly influenced by all the elements that make understanding the broad warfighting ethos of a people, nation, or armed force, a difficult proposition. Understanding AI developed by a particular nation will be as complex as understanding that nation as an adversary. The culture, ethos, morality, ethics, and a myriad of other factors pertaining to the potential adversary would have to be studied to understand the AI developed by that adversary. Even after such analysis is done, there will always remain a certain percentage of unknown developments that have taken place. In the warfighting dimension, understanding AI is almost like understanding a human warfighter; it will be as complex and unpredictable as human beings.

AI AND AIR FORCE FOCAL POINTS

The foundations of a military force that generates, applies, and sustains air power – normally an air force – are based on four focal points: capability, concepts, organisation, and people. These four focal points have to be maintained in a pre-set balance for the force to function at optimum efficiency; the balance being calculated, taking into account a number of variables and their interaction with each other. Even minor changes to the strategic framework of the force will have cascading effects and will definitely alter the relative and fine balance between the focal points. These changes to the balance and the arrival at new balancing points are necessary to ensure that the force retains its inherent flexibility and agility, and that it remains efficient.

Capability development has to be based on a realistic threat assessment and meeting the strategic needs of government. There are four determinants that are fundamental to the success of the capability development process. One, the nation's ability to resource the necessary capabilities through indigenous development or external acquisition. Two, the veracity of the future strategic assessments to derive the threats to the nation and responses to them. Three, the ability of the capability development process to integrate directly to the concept of operations and establish a cyclical relationship with it. And four, to be able to maintain a continuous and open-ended process that caters for the need to be flexible and agile when any of the three other fundamental determinants of capability development change or are disrupted. The impact of AI on capability development will be indirect, felt through the necessary changes that will have to be made in the concepts of operations.

Innovative **concepts** of operations are hallmarks of professional air forces and maximise the effectiveness of available capabilities in achieving strategic objectives. This combination of sophisticated capabilities and innovative concepts of operations creates the necessary and focused effects needed to achieve the strategic intent of the nation through the application of cutting-edge air power. The unrestricted employment of AI will manifest in having to alter, recreate, and further fine-tune the concepts of operations in order to take advantage of the enhanced freedom that would come with the removal of the threat to friendly human beings. In turn, the conduct of the four core roles of air power – control of the air, strike, air mobility, and ISR – would also be considerably altered. At the fundamental level, air power will continue to carry out its roles, but the manner in which they are conducted will change radically. It can be envisaged that attrition tolerance will improve, especially when the systems being operated are relatively cheaper and more expendable since human lives would not be at stake.

The induction of AI and its influence on the development of concepts of operations would have far-reaching consequences. It would require a complete overhaul of the existing command and control (C2) structure, which is primarily based on the availability of a human being in the decision-making loop – at least to provide a veto option if required. The C2 structure that would permit the unrestricted employment of AI will need to remove the human element from the operational and tactical levels of functioning. Even at the strategic level, human input would necessarily be limited to giving the approval for a campaign to be conducted and then letting AI have full control of planning, execution, assessment, and re-planning or necessary planning of the missions to achieve strategic objectives. The absolute basic change in the whole process is that the 'human veto' function that has so far existed in all aspects of the application of air power – from the strategic to the tactical – will no longer exist.

At the apex of national security decision-making, a human element will need to remain in executive control. Therefore, the integration between the autonomous systems and the strategic decision-making cycle would have to be worked out minutely and precisely. Whether or not this integration is achieved purely through AI or a combination of AI-human elements will depend on a number of extraneous factors and would vary from nation to nation.

The increased versatility that AI will potentially bring to the application of air power can only be fully exploited by an **organisation** that provides a flexible framework for its holistic employment. The framework should also be flexible enough to cater for the continual changes that will ensure the generation and sustainment of air power at the required level. Further, an agile organisation is a foundational requirement for the generation, application, and sustainment of air power that is fundamentally oriented towards accepting and operationalising the concepts of operations to fully exploit the unrestricted usage of AI. The most important capacity that an agile organisational structure brings to the application of air power is the inherent flexibility that comes with it at the strategic level. Only organisations that are created with inherent flexibility will, in turn, be able to create the necessary sub-structures with sufficient flexibility. The full-spectrum usage of AI can only be undertaken with an organisation that has agile and flexible structures at all levels. The requirement is for the organisation to be fully versatile from the strategic to the tactical level while retaining the soundness of the structure.

People of calibre have always been, and will continue to be, the key to creating an effective air force to deliver air power. People are the key to force-wide flexibility and the critical link in the chain that keeps the cycle of generation, application, and sustainment unbroken.

This cyclical chain could be as long or as short as possible, depending on the context of the application that is being envisaged. The ability to extend or shorten the cycle is a factor of the overall flexibility inherent in air power and is also a function of the professionalism of the people involved.

All fighting forces are influenced by the events of the past and use them as building blocks to create and maintain the fighting spirit essential to win in future combat situations. To some extent, glorification of the exploits of the past is also resorted to in order to sustain the fighting ethos of the force. These are people-oriented activities. However, with the introduction of AI-based autonomy into operations, the need to create *esprit de corps* among warfighters may diminish considerably. It will follow that the current selection process, training, and employment regime for airmen would become redundant. A combat force based on the autonomous employment of AI would need to develop a different process for the selection, training and employment of its personnel. AI-based autonomy in mission control will bring a step-change function and new paradigms to the employment of air power across the spectrum of its application. In this context, the past – while it should not be forgotten – does not provide any tangible pointers to the future. The only assurance is that air power capabilities, concepts, organisation, and the people who employ it will all evolve into something completely unlike what is normal today.

CONCLUSION

With the advent of AI, a new horizon is looming in the firmament regarding the future of air power. Air power is about to plunge into a great unknown of both risks and opportunities. It will be a failing force that does not recognise this reality and/or take appropriate actions to ensure that the advantages are captured and the challenges addressed. The adage, 'first in will be best dressed' applies to the understanding and leveraging of AI. The development trajectory of air power has arrived at a situation reminiscent of an earlier time between 1918 and 1935, when large numbers of theories regarding its effective employment were developed and advocated. Most of these were based on conjecture and were often buttressed by some wishful thinking. The flights of fancy were unavoidable at that time, because there was no explicit experience to act as the foundations for the development of theories, concepts, and doctrine.

The introduction of AI will bring air power to a similar juncture. Today there is no background experience to base developmental thinking, create theories and concepts of employment for an AI-based fully autonomous system. There is no option but to chart a course into the unknown, a course that should run parallel to the maturing of the autonomous systems' operational capabilities and their acceptance into the day-to-day functioning of a force. Failure to make the necessary critical changes to ameliorate the emerging challenges, failure to adapt to the ever-changing future, failure to jettison the baggage of the future, failure to accept the momentous changes already in train, individually as airmen and collectively as an air force, will lead to catastrophic failure of the force.

With the advent of AI, air forces – still the primary generators of air power – are on the cusp of an oncoming, and as yet unfathomable but momentous step-change.

"In the early twenty-first century, the train of progress is again pulling out of the station – and this will probably be the last train ever to leave the station called Homo Sapiens. Those who miss this train will never get a second chance. In order to get a seat on it you need to understand twenty-first century technology, and in particular the powers of bio technology and computer algorithms... those left behind will face extinction."

Yuval Noah Harari,
Homo Deus: A Brief History of Tomorrow, 2015.

CHIEF OF AIR FORCE, SKYHAWK DEDICATION, OHAKEA, MARCH 2019.

HOW VIRTUAL REALITY IS RESHAPING THE FUTURE OF TRAINING AND DEVELOPMENT

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INTRODUCTION

The virtual reality (VR) industry has experienced rapid advances in technology and capability in the last five years. This has led to increased adoption of VR, particularly as a training solution.

VR is a synthesis of wearable computer hardware and specialist software that delivers images to the operator via small high-resolution screens mounted within a headset worn over the eyes. The software images create a 'virtual world' that the user can interact with and manipulate in real time.[1]

This essay will consider the recent advancements in VR technology and its application as a powerful immersive training device. Firstly, the origins of simulators and virtual reality will be explained. Secondly, some of the current applications of VR in the training environment will be detailed – with particular focus on flight training. Finally, potential applications of VR will be presented – including applicability to air power – along with the general advantages and disadvantages of the technology.

A better understanding of what VR is and how it can be utilised in the learning and development environment is essential to enable leaders to make informed decisions regarding its adaptation and implementation.
In particular, current users of legacy immersive training solutions, such as flight simulators, are well positioned to incorporate VR into their existing training systems.

A BRIEF HISTORY OF FLIGHT SIMULATORS AND VIRTUAL REALITY

Since the 1920s, organisations responsible for flight training have used simulator technology in order "to reduce costs, extend aircraft life, maintain flying proficiency, and provide more effective training, especially in areas difficult to train in operational aircraft."[2] Flight simulators have advanced a great deal since Edwin Link invented the *Link Trainer* in 1929 – from humble beginnings that featured wooden frames and pneumatic bellows for movement, to the present day six axis, glass cockpit, complex full flight simulators (FFS). These include all of the equipment and the computer programmes necessary to represent the aircraft's operations and are extremely sophisticated. Using a FFS, it is possible to train and qualify pilots from zero hours of experience on that type of aircraft. According to *Markets and Markets*, a

1 Burdea & Coiffet, *Virtual Reality Technology.*

2 Taylor, Talleur & Rantanen, "Transfer of Training Effectiveness of a Flight Training Device (FTD)."

THE USE OF VR AUGMENTS PILOT TRAINING, SAVING ON EXPENSIVE RESOURCES AND TIME.

leading business to business analytics company, growth in the flight simulator market is expected to reach US $7.7 billion by 2025, representing a compound annual growth rate (CAGR) of 5.2% from 2019.[3] Costing several million dollars each, this value will predominantly comprise the purchase and operating costs of a FFS.

With the popularisation of the home personal computer (PC) in the 1980s, the world of flight simulation was made available to the general public. As PCs have become more powerful, flight simulation software has become more sophisticated. Applications such as Laminar Research's *X-Plane* and Lockheed Martin's *Prepar3D* are now leading the way in the consumer flight simulator marketplace with software that delivers texture, graphics, and scenery at unprecedented levels of quality. Unlike previous incarnations, home flight simulator pilots now have the ability to fly any aircraft, in any condition of their choosing, anywhere in the world. Given the right hardware, this ability has opened up a new horizon for flight simulator software. Consumer technology and home flight simulator 'rigs' can only deliver so much. One or two monitors, a joystick, and possibly a throttle quadrant falls significantly short of providing the immersion and realism required for professional flight training as delivered by a FFS.

The rapid advances in technology and the capabilities of VR have significantly bridged the gap between professional FFS and consumer flight simulators, making VR a viable flight training alternative. VR has been around in various forms since the 1960s. Due to the high cost and the severe limitations of the technology, historically VR was only used by those institutions with enough finances to afford it, such as academic and military institutions. This changed in 2014 when the CEO of Facebook, Mark Zuckerberg, bought a tech start-up named *Oculus VR* for US $2 billion.[4] The Oculus acquisition prompted an exponential increase in the interest of VR, which has led to growing innovation, investment, and excitement around the VR technology industry over the last few years. This interest and innovation is accelerating as demonstrated by the number of top tier hardware and software manufacturers like HTC,[5] Sony,[6] Samsung,[7] and Valve[8] that have entered the VR market over the last few years.

The miniaturisation of small, very high resolution displays and the availability of lightweight materials has led to rapid advancements in head-mounted display (HMD) technology. Unlike earlier models, which often induced 'simulator sickness', newer generation HMDs greatly reduce these side effects by delivering graphics with crisp rendering and smooth tracking information. Audio information is also delivered via the HMD, or through remote external speakers. Physical interaction with the virtual world, known as haptics (Greek: *haptikos*, meaning 'able to come into contact'),[9] is achieved through a combination of commercial off-the-shelf (COTS) specialist hardware, such as flight controls and medical devices, and/or

3 Markets and Markets, "Flight Simulator Market by Platform."

4 Bailenson, *Experience on Demand: What Virtual Reality Is, How It Works, and What It Can Do.*
5 Vive, *Vive*, "What is High End Virtual Reality?"
6 Sony, *Playstation VR*.
7 Samsung, *Samsung Gear VR*.
8 Valve, *Virtual Reality on Steam*.
9 Lanier, *Dawn of the New Everything: A Journey Through Virtual Reality*.

clothing devices, such as gloves and other garments that provide sensation feedback. In addition, it is worth noting that rapid advancements in 'hand gesture' recognition technology are currently taking place in this area. Although a significant advancement, hand gestures cannot provide haptic feedback without physical hardware. Wireless multifunction handsets that are detected by the HMD are also used to point and click virtual articles within the VR environment. As a result of these developments, VR hardware in concert with computer hardware and software now has the versatility to represent myriad environments to a never-before-seen degree of realism. Coupled with previously unachievable levels of interaction, VR now has the ability to deliver high-fidelity total immersion training experiences.

VR APPLICATIONS – FLIGHT TRAINING

VR now presents a viable alternative to traditional flight simulators, with the ability to deliver high-value, realistic, and effective flight training at lower cost than traditional simulators. In addition, VR can easily and quickly be reconfigured to represent different aircraft without the need to own or operate additional physical simulators. The United States Air Force (USAF), for example, is taking advantage of simple VR simulator setups, comprising an HMD, control stick, throttle, rudder pedals, monitors and a stationary seat. These VR rigs, although basic in appearance, are reducing the number of expensive, time-consuming flights that students require in real training aircraft.[10] Additionally, with the modularity and networking capability of VR and the emergence of products like CAE TRAX,[11] students can learn and practice independently, aided by 'virtual coaches.' This will leave instructors with the time and freedom to monitor the progress of multiple students, while also optimising the airborne flight training hours.[12] Several studies have found that VR training improved productivity and flight experience, especially in areas of critical factor recognition, decision-making skills, situational awareness, and crew coordination.[13 14 15] These studies into the effectiveness of VR as a flight training aid strongly support the use of the technology as a viable addition or alternative to the traditional methods currently employed. VR flight training is also less dependent upon factors such as the availability of aircraft, simulator, or instructor; while the weather, maintenance, and other logistics requirements have a much lower impact on training.[16] VR gives student pilots more opportunities to train – either at work or in their accommodation – cooperatively with peers or instructors in realistic scenarios that further hone their skills.[17] USAF flight instructors reported that VR students' ability to practice virtually – prior to flying an actual training aircraft – lead to them being 'leaps and bounds' ahead of their legacy peers.[18] These same

10 Pope, *A Cost-Benefit Analysis of Pilot Training Next*.

11 CAE Defence, *CAE TRAX*, Academy "Pilot Training Continuum."
12 Ibid.
13 Estrada, Adam & Leduc, "Use of Simulator Spatial Disorientation Awareness Training Scenarios by the U.S. Army and National Guard."
14 Buttussi & Chittaro, "Assessing Knowledge Retention of an Immersive Serious Game vs. a Traditional Education Method in Aviation Safety," 529-538.
15 Bowman & McMahan, *Virtual Reality: How Much Immersion Is Enough?* 36-43.
16 Pope, *A Cost-Benefit Analysis of Pilot Training Next*.
17 Ibid.
18 Pope, *A Cost-Benefit Analysis of Pilot Training Next*.

A MASSEY AVIATION SCHOOL FLIGHT INSTRUCTOR CONDUCTS TESTING ON A PROTOTYPE VR FLIGHT TRAINING DEVICE.

students were reported to be at least as good, if not better, than their contemporaries at the same stage of flight training, and some students were capable of feats that are rare in traditional training, including landing without instructor intervention on their first flight in the real training aircraft.[19] Students engaged in the USAF programme were found to be unbound by the stressors of traditional 'lockstep' pass/fail timelines, which lead to exploration at the individual's learning level, both during on-duty and off-duty hours.[20] Furthermore the reports indicated that significant savings can be made both in financial terms – such as fewer airframe hours, less fuel, less maintenance – and in terms of a reduction in the time it takes to graduate qualified pilots.[21] The versatility and cost effectiveness of VR as a full immersion training solution also means that it can be considered for other types of flight training applications, such as unmanned aerial vehicle (UAV) operations.

19 Pope, *A Cost-Benefit Analysis of Pilot Training Next*.
20 Ibid.
21 Ibid.

OTHER APPLICATIONS

In an era of stringent occupational health and safety legislation, it is becoming increasingly difficult to manage the inherent higher risk of training personnel involved in high consequence activities, while also maintaining organisational peak performance by utilising low risk, low consequence virtual environments. VR is enabling industry to train using new, improved, and safer methods that would previously have been too difficult or too dangerous to consider. Effective training often requires individuals or teams to undertake realistic and vocationally relevant scenario-based training exercises. The recent improvements in VR technology are leading to growing interest and use among high-consequence industries.[22] The increased adoption in many instances occurs in industries not usually considered traditional users of computer simulators.

Learning is a holistic process of adaptation and not just cognition; it involves a learning cycle of thinking, feeling, perceiving, and behaving.[23] VR enables industries to conduct realistic training that supports this learning method in safe, controlled environments with no consequences for failure. Fire-fighters are now able to fight fires in virtual reality environments such as large bush fires or structures, which, prior to VR, would have been impractical or too dangerous.[24] Athletes are using VR to conduct immersive performance-based

22 Wentworth, *The Impact and Potential of Virtual Reality Training in High-Consequence Industries*.
23 Kolb & Kolb, "*Experiential Learning Theory: A Dynamic, Holistic Approach to Management Learning, Education and Development*."
24 Nahavandi, et al. "Haptically-Enabled VR-Based Immersive Fire Fighting Training Simulator," 11-21.

analysis, enabling them to improve coordination and decision-making.[25] Surgeons are able to practice procedures and hone their skills countless times without endangering life.[26] Using VR removes the risk to life and limb that can often be associated with live scenario-based training. VR learning can be customised and optimised to specifically meet an individual's ability and rate of learning, further enhancing the experience. Training exercises can be run and re-run countless times, in which it is possible to change only one or two variables and observe new effects and consequences. Haptic hardware devices (such as firefighting hose branch equipment[27] and surgical implements) [28] created by newly emerging technology manufactures are adding further realism to the VR learning process. Physical feedback, where utilised, enables professionals to practice and train in a safe, controlled, repeatable environment. As hardware capabilities continue to advance according to Moore's Law,[29] the technology and capability of VR will likewise continue to evolve and increase.

25 Bailenson, *Experience on Demand: What Virtual Reality Is, How It Works, and What It Can Do*.
26 Fundamental Surgery. "Welcome to Fundamental Surgery."
27 FLAIM Ltd, "FLAIM Trainer Overview."
28 Twinn, "Fundamental Surgery Showcase HAPTX gloves on Fundamental Surgery."
29 Lexico, *Definition of Moore's Law in English*.

THE FUTURE

Fully immersive training experiences will play a significant role in the future of training and drastically change the methods currently employed by the learning and development industry. Interest in VR is driving increased innovation and investment in the industry, which will see the market grow from an estimated US $29.2 billion in 2019 to over US $147 billion by 2022, a CAGR of 71.6% during this period.[30] The next generation of employees have engaged with digital multimedia technology from birth. In order to fully engage with these employees, companies will need to consider moving away from and augmenting traditional forms of delivering training, such as two-dimensional computer-based training and PowerPoint presentations. Studies have shown that individuals who have undertaken VR training demonstrate faster learning and increased knowledge retention over those using standard training methodologies.[31] Recent technological developments like the arrival of fifth generation (5G) mobile networking, untethered HMD hardware, tactile feedback haptics, and omnidirectional moving floors will further add to the fully immersive experience offered by VR. These advances also make the technology easily deployable and, as such, are a realistically viable option for military utilisation.

Fully immersive VR training is currently at a stage where it could be readily employed in many areas across the RNZAF. The technology could be utilised to provide vocation-specific training to personnel involved in a number of trades, such as fire-fighters,

30 Rishi & Saluja, *Future of IoT*.
31 Krokos, Plaisant & Varshney, *Virtual Reality*, 1-15.

THE UNITED STATES AIR FORCE AIR EDUCATION AND TRAINING COMMAND IS EMBRACING VR TECHNOLOGY THROUGH ITS PILOT TRAINING NEXT DEVELOPMENT PROGRAMME.

medics, logistics specialists, aircraft maintenance/engineering personnel and air crew. Allied air forces, including the Royal Air Force (RAF), United States Air Force (USAF) and Royal Australian Air Force (RAAF) are already utilising VR pilot training to various degrees and with positive results.[32] The USAF implementation, Pilot Training Next (PTN),[33] is a trial programme aimed at investigating the viability of VR to train the next generation of pilots, as well as address the current pilot shortage being experienced. Senior UK Ministry of Defence (MoD) and RAF personnel have visited the USAF PTN facilities, and RAF trainee pilots and instructors have undertaken and subsequently graduated from the programme.[34] Initial analysis of PTN indicates that significant time and cost savings can be made by incorporating or replacing traditional flight training methods with VR flight training.[35] Better utilisation of training time allocations, fewer delays or cancellations due to weather or unavailability of aircraft due to maintenance issues results in less time required to train pilots. A reduction in airframe hours and fuel usage, less maintenance, and a marked reduction in the associated ancillary logistic costs means additional financial savings. By adopting PTN, it is estimated that the USAF, and thus the American taxpayer, could save approximately US $13bn over the next ten years.[36] VR training in multiple disciplines, not just flight training, offers the ability to make significant time and economic savings over current methods. While the RNZAF and the wider NZDF community are conducting some investigations and making use of VR in isolation – a concerted, centrally-managed capability project would create opportunities to fully identify how and where VR could be utilised for maximum benefit. With increased scrutiny on government spending, the MoD and the RNZAF should consider VR as an increasingly viable option for delivering cost effective, high quality, realistic, and safe training in an increasingly technological age.

32 Pope, *A Cost-Benefit Analysis of Pilot Training Next*.
33 Pennington, et al. *Integration of Advanced Technology in Initial Flight Training*, 1-5.
34 Hawkins, *RAF Partners with PTN to Innovate Pilot Training Pipeline*.
35 Pope, *A Cost-Benefit Analysis of Pilot Training Next*.
36 Ibid.

SUMMARY OF SOME ADVANTAGES AND DISADVANTAGES OF ADOPTING VIRTUAL REALITY TRAINING

ADVANTAGES		DISADVANTAGES	
SAFETY	Training performed in a safe, controlled 'simulated' environment.	MOVEMENT	Currently there are still some limitations around freedom of movement, such as walking or running. Emerging technology is beginning to address this.
COST	Cheaper, when compared to operational hardware in terms of set-up and operating costs. Reduced operational and training costs.	PHYSICAL DISCONNECT	Inability to see through the HMD. The virtual environment often needs to replicate the physical environment. Advancements in mixed reality (MR) will address this.
VERSATILE	Has the ability to quickly and easily simulate multiple environments or scenarios at little or no extra cost.	MOTION SICKNESS	Potential to experience simulator-induced motion sickness – mitigated by better technology and repeated exposure.
EFFICIENT	Offers a more effective use of available training time and delivers better results than traditional ground training options.	DESENSITISATION	Training may be viewed as a video game if not delivered correctly.
ECOLOGICAL	Offers a greener solution to traditional forms of training, which lowers the organisational carbon footprint.	ADDICTION	As in the gaming experience, some operators might become overly immersed in the virtual world.
TRAINING FAMILIARITY	Provides the ability to train, rehearse, or pre-train for known situations.	OBSOLESCENCE	The very fast pace of this technology will require frequent HMD upgrades. Costs will continue to reduce over time.

CONDUCTING SURGERY WITH HAPTX GLOVES.

CONCLUSION

The VR industry as a whole has experienced rapid developments in technology and capability over the last few years. As a result of this, VR now has the capability to deliver high-fidelity immersive training and the versatility to represent myriad environments in unprecedented levels of realism. Coupled with previously unachievable interaction with the virtual environment, these advancements mean that users of legacy training solutions are very well positioned to incorporate VR into their existing training systems. The benefits of VR training, particularly in aviation, are becoming increasingly well documented and independent studies into its effectiveness have found that students show increased knowledge retention, faster acclimation, and superior performance when compared to trainees on legacy systems. Furthermore, significant savings can be made in both training time and cost. With multiple RNAZF units required to provide ongoing training support to personnel, VR could play a significant role in facilitating this goal in a safe, controlled, repeatable, and cost-effective manner. With recent technological developments also taken into consideration – including untethered HMD hardware, virtual coaches, tactile feedback haptics, and omnidirectional moving floors – the versatility and capabilities of VR will continue to grow. Centralised investment of time and resources into VR capability projects will permit early adoption of this technology by the RNZAF. This will enable the RNZAF and the wider NZDF community to take full advantage of new educational tools and lead the way in the use of the latest in adaptable and cutting-edge training technology. VR training represents an economically sound, low risk, high quality augmentation to many traditional training systems. Further investment and investigation in this area should be seriously considered by the RNZAF and NZDF if they wish to remain at the leading edge of technological advancement.

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3 SQUADRON GROUND CREW CLEANING VEHICLES: EX TALISMAN SABRE, 2019.

BOOK REVIEW – THE GUINEA PIG CLUB: ARCHIBALD MCINDOE AND THE RAF IN WORLD WAR II

REVIEWED BY LOUISA HORMANN | ARCHIVES TECHNICIAN
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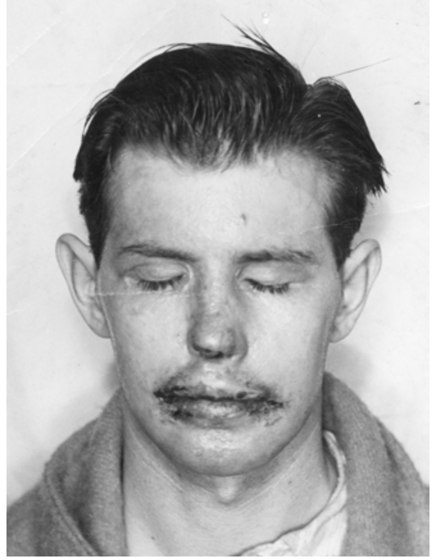
The Guinea Pig Club: Archibald McIndoe and the RAF in World War II is the 2018 revised edition of *The Reconstruction of Warriors: Archibald McIndoe, the Royal Air Force and the Guinea Pig Club* (2004). Developed from her 2003 PhD thesis, which centred on extensive research into official records and first-person recollections, Mayhew's first edition explored the relationship between the Guinea Pig Club, the RAF, and the British Home Front. These connections should be emphasised because the Club's success was, as HRH Prince Harry, Duke of Sussex writes, "the result of the integration of medical and social support that was instrumental to the rehabilitation and confidence of injured servicemen."

The Guinea Pig Club was formed in 1941 by and for RAF and Allied aircrew undergoing gruelling burns surgery at Queen Victoria Hospital in East Grinstead, England. Not all RAF casualties were treated at East Grinstead, but all members of the Club were treated by the pioneering New Zealand plastic surgeon, Sir Archibald McIndoe. While Mayhew's main text remains unaltered, *The Guinea Pig Club* was republished amidst renewed British interest in this history. The Club's example – having held its final reunion in 2007 – is now used to inspire today's modern wounded veterans, specifically through the 2017 establishment of the CASEVAC Club – after 'casualty evacuation' – for severely injured British veterans of Iraq and Afghanistan.

Like other recent air power histories of World War II, Mayhew dispels the myth that burned aircrew were mainly *Battle of Britain* fighter pilots, to prove that from 1941-1945, the vast majority served in Bomber Command. She does, however, focus the second and third chapters on the lasting impact of those first *Battle of Britain* casualties on medical developments and the club's founding. Chapters four and five describe the inevitable influx of Bomber Command casualties and the establishment of the Canadian Wing and POW treatment. Throughout, Mayhew successfully draws clear links between her analysis of inter-war technologies and policies in chapter one and how these shaped the new and escalating crisis of casualty-by-fire. The final two chapters focus on the Club's many legacies, including the advocacy work of its members post-war.

A military medical historian, Mayhew also has a personal connection to her subject. Her grandmother worked at East Grinstead for Archibald McIndoe, the civilian consultant to the RAF and Guinea Pig Club president. This edition is prefixed with a note on McIndoe's early life, though New Zealand readers will notice 'Otago High School' with its McIndoe House, is more correctly known as Otago Boys' High School, formerly Dunedin High School. Nonetheless, this addition provides background context to McIndoe's unique persona as someone unafraid to fight the authorities, successfully campaigning to end coagulation therapy – use of tannic acid to seal burned tissue – and for patients to wear RAF uniforms instead of regulation hospital 'blues'. Other radical initiatives enabled patients to view operations and encouraged their interaction with the wider East Grinstead community. Mayhew's treatment of the aviation context and military and civilian aspects, is well-balanced, however, there might have been more focus on the medical developments, given it was still such an emerging field. To expand on this subject from a New Zealand perspective, I would add Murray Meikle's 2013 novel *Reconstructing Faces: The Art and Wartime Surgery of Gillies, Pickerill, McIndoe and Mowlem* (Otago University Press) to Mayhew's extensive suggested reading list. However, *The Guinea Pig Club* is still the most recent, comprehensive monograph on the history of the Guinea Pig Club, and important reading for learning how McIndoe's holistic approach to patient care changed the medical and social treatment of human disfigurement.

NEW ZEALAND WIRELESS OPERATOR/AIR GUNNER FLIGHT LIEUTENANT VERNON ERNEST MITCHELL IN THE EARLY STAGES OF BURNS SURGERY, FOLLOWING AN AIRCRAFT ACCIDENT. AIR FORCE MUSEUM OF NEW ZEALAND.



MITCHELL WAS ONE OF OVER 170 INTERNATIONAL 'GUINEA PIGS', MAKING UP A QUARTER OF THE CLUB'S TOTAL 649-STRONG MEMBERSHIP.

HERE, HE IS PICTURED DURING LATER STAGES OF RECONSTRUCTIVE SURGERY. FROM THE COLLECTION OF THE AIR FORCE MUSEUM OF NEW ZEALAND.

BLACK FALCONS,
OCTOBER 2019.

BOOK REVIEW – MANY A CLOSE RUN THING: FROM JET-FIGHTER PILOT TO AIRLINE CAPTAIN

REVIEWED BY SQNLDR PAUL STOCKLEY | FLIGHT INSTRUCTOR
ROYAL NEW ZEALAND AIR FORCE BASE OHAKEA

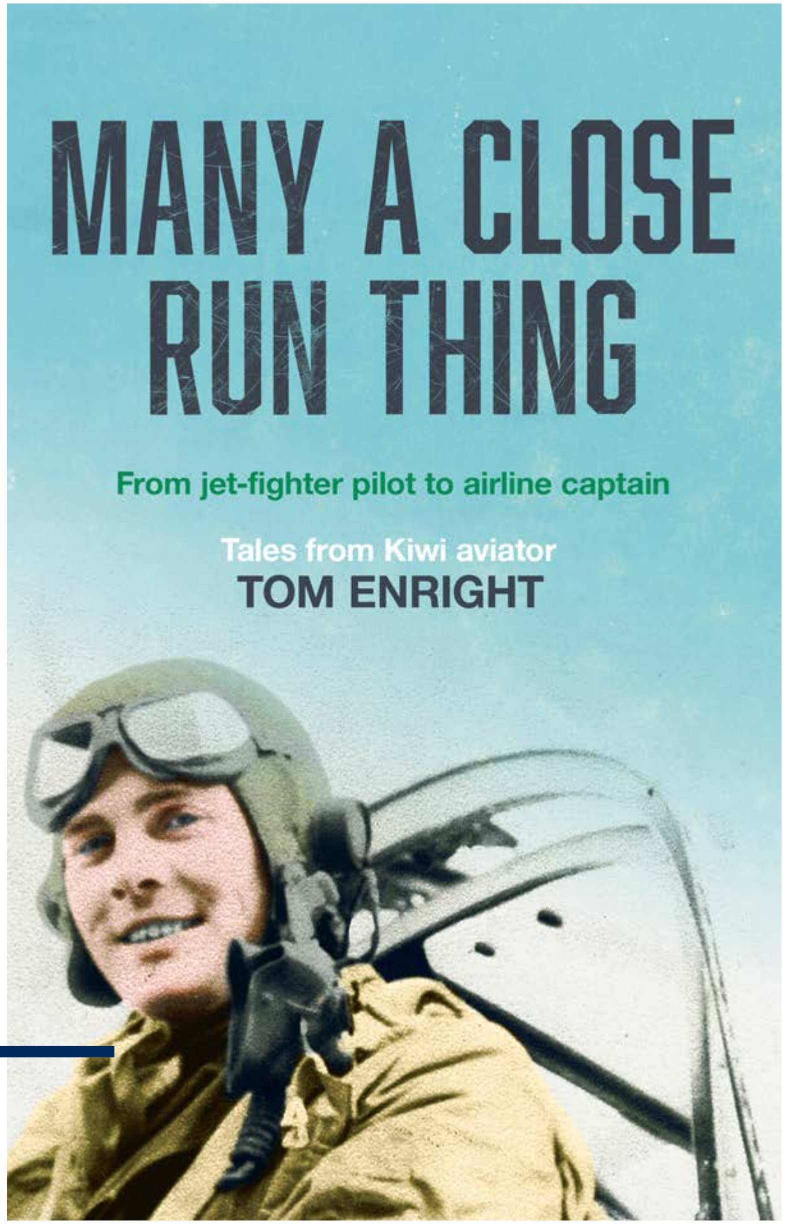
Peruse the history shelves of any good bookstore and you will find many accounts, both personal and analytical, of combat flying and employment of air power during conflict. The majority of aircrew biographies and autobiographies are focused on wartime operations, highlighting the heightened tension, excitement and danger associated with this aspect of military aviation. However, in doing so, these accounts inadvertently suggest that peacetime flying is less hazardous, exhilarating, strained, and subsequently not as interesting. Perhaps the lack of 'peacetime' aircrew accounts to be found on the bookshelves is a reflection of this suggestion. The publication of a new book that goes a long way toward dispelling this implication is therefore both welcome and overdue.

Many A Close Run Thing is the aviation story of Tom Enright, a professional pilot whose eclectic flying career included time as a military fighter pilot, maritime patrol aircraft commander and airline captain. Starting on Tiger Moths and ending on Boeing 747s, Tom's flying experience also includes many hours on Vampire jets, Sunderland flying boats, and P-3 Orions. The title of the book is a giveaway that, even though he was not involved in wartime operations, there were many, many times when Tom was subject to tension, excitement, and danger of the highest order. Crash landing a Vampire into a field following an engine failure, coming within metres of the ground following a display manoeuvre that went wrong, and saving a Sunderland from descending into terrain during a severe microburst, are just three events that highlight just how close things can be, even in peacetime.

A highly readable account, *Many a Close Run Thing* is a fascinating insight into military flying with the Royal Air Force and Royal New Zealand Air Force during the 1950s and 60s, and airline flying in the 1970s and 80s. However, *Many a Close Run Thing* is not an authoritative work, merely a personal recollection. As such, there are a few factual inaccuracies within, not with respect to what Tom did but with respect to some of the broader anecdotes. For example, stating that the Rolls Royce Griffon was an American engine. While not a biggie for most readers, for the purist these errors may jar.

One other aspect that jarred for this reviewer was the inclusion of two chapters that seem completely out of place and context within what is otherwise a flowing autobiography. The first is an arbitrary chapter on Tim Wallis shoehorned between recollections of Sunderland and P-3 Orion flights. The second is a treatise on Malaysian Airlines Flight 370 and the author's opinions regarding its disappearance.

Notwithstanding the above, *Many a Close Run Thing* is well worth a read as it relates to a period of time where few personal RNZAF aircrew accounts have been published to date and Tom has told his story in a very engaging manner. *Many a Close Run Thing* also demonstrates that peacetime operations can be just as hair raising and exciting as those conducted during war.



COVER DESIGNED BY DARREN HOLT, HAPERCOLLINS DESIGN STUDIO. COVER IMAGE FROM TOM ENRIGHT'S PERSONAL COLLECTION.