WINGS

SPRING 2022
VOLUME 74 NO.3

X-PLANES
BREAKING THE SOUND BARRIER

THE RED ARROWS
RAF AEROBATIC TEAM

ZOOT SUITS
PREVENTING PILOT BLACKOUTS

GOING TO EXTREMES
RADICAL DESIGNS FROM SKUNK WORKS

AUS $14.95 (Incl. GST)
03
ISSN 2653-2050
9 772653 205002

AIR FORCE ASSOCIATION MAGAZINE
-ESTABLISHED 1943-

The credit card that has tails wagging.

Introducing Australia's Defence Bank Foundation VISA Credit card. It's a win for members, a win for veterans and a win for specially-trained dogs like Bruce, whose handsome face appears on the card.

3.99% p.a.
6 month introductory rate*.

8.99% p.a.
Ongoing rate*.

- **Up to 55 days interest free on purchases.**
- **Same low rate for purchases and cash advances.**
- **Additional cardholder at no extra cost.**

Australia's Defence Bank Foundation supports the Defence Community Dogs' Program. It provides specially-trained assistance dogs to veterans living with post-traumatic stress disorder (PTSD). Thanks to you, we'll donate half of the annual card fee every year to do what we can to serve those who protect us.

Defence Bank

defencebank.com.au
1800 033 139

Scan the QR code or visit our website to find out why this credit card is getting tongues and tails wagging.

mozo EXPERTS CHOICE 2021 LOW RATE CREDIT CARD

*Rates are current as 1 October 2020 and subject to change. Introductory rate is applicable for the first six months and then reverts to the variable credit card rate, currently 8.99% p.a. Credit eligibility criteria, terms and conditions, fees and charges apply. Before acquiring any product please consider whether it is right for you and refer to Defence Bank's Products and Services – Conditions of Use and Target Market Determination found at defencebank.com.au. Card is issued by Defence Bank Limited ABN 57 087 651 385 AFSL / Australian Credit Licence 234582.

MANAGING EDITOR'S MESSAGE

THE SPRING 2022 EDITION of *Wings* magazine is the 13th produced by RAAFANSW Publications Pty Ltd. From the outset we aimed to deliver an informative and entertaining magazine to engage the aviation minded and to lift the Air Force Association profile with retired and serving veterans alike. Feedback indicates we are achieving both objectives.

In this edition we feature The Red Arrows, the Royal Air Force's formation display team, and continue to delve into early space exploration and some of the unusual aircraft concepts considered during the early surge of air power evolution. We also present an intriguing story on the Australian influence on early anti-g suit development. Defence Science and Technology Group outlines a research program to explore a process to enable military combatants to become battlefield 'prosumers', customers directly involved in the production of equipment and tools to be used in the battle taking place.

Visit our website, wingsmagazine.org, and arrange a personal or gift subscription to receive a regular copy in the mail and to access the magazine online.

Ron Haack,
Wings *managing editor*

WINGS EDITORIAL DEADLINES 2022/23

Wings welcomes editorial submissions and letters to the editor. Please note the following deadlines for submissions.

EDITION	DEADLINE
Summer (December)	14 October 2022
Autumn (March)	20 February 2023
Winter (June)	17 April 2023

Please send submissions and letters to: managing.editor@raafapublications.org.au, includingyour name and details. Submissions maybe edited for length and clarity. We cannot guarantee all material will be published.

air force association

CONTENTS

WINGS SPRING 2022 VOLUME 74/NO.3

MESSAGE FROM THE

FORMER CHIEF OF AIR FORCE

WELCOME TO THE SPRING EDITION OF *WINGS*, an edition that continues to provide productive thought, updates and news on key topics. This is valuable to those who want to stay in touch with the important work and achievements of our Air Force as it delivers for our nation's security. I am extremely proud of the professionalism, skill and dedication of our aviators as our Air Force moves into its second century, and I commend this edition to you.

On 1 July, I handed Command of the Air Force to Air Marshal Rob Chipman, with a parade on a bitterly cold and wet day at Russell Offices, Canberra. Those on parade were soaked, and I am humbled by their commitment for the ceremony. I was also amazed and exhilarated by the skill of our No.1 Squadron Super Hornet crews who successfully completed a flypast in very challenging weather.

Together with receiving the Chief of Air Force pennant that had flown during my tenure, from Warrant Officer – Air Force Fee Grasby, all contributed to strong emotions as my wife, Lou, and I passed the weight of Command to Rob and his wife Alyce. In that moment, I also reflected on the immense contribution of partners, families and friends in supporting all who serve in our Air Force.

As this edition of *Wings* will affirm, Air Force is in good shape. With excellence and the strength of leadership of Rob Chipman, Air Force is well placed to meet the challenges that our current strategic circumstances will throw at us. Rob, as the Chief of Air Force, is the lead for the Air and Space Domains and capabilities such as Integrated Air and Missile Defence, Hypersonics and the uncrewed air combat system represented by the Ghost Bat Loyal Wingman program. It is an exciting time for our Air Force as part of an integrated and joint force.

So, while now supporting from my front verandah on the coast, I look back over my career in the Air Force with fond memories and feel privileged to have worked with such amazing people throughout.

Per Ardua ad Astra.

AIRMSHL (Retd) Mel Hupfeld,
Former Chief of Air Force

ABOVE Air Marshal Mel Hupfeld and Mrs Louise Hupfeld (right) with Air Marshal Robert Chipman and Mrs Alyce Chipman at the transfer of commander ceremony outside Air Force Headquarters in Canberra. Photo: LAC Adam Abela.

ON THE COVER
Red 6 and 7 fly a dramatic opposite direction splinter through the main Red 1-5 Vic formation. Photo: SAC Abigail Drewett/UK MOD © Crown copyright 2022.

WINGS TEAM

MANAGING EDITOR Ron Haack
EDITOR Sandy McPhie
ART DIRECTOR Katie Monin
SENIOR ADVERTISING EXECUTIVE Sue Guymer
ADVERTISING EXECUTIVE Phil Whiteman
BUSINESS DEVELOPMENT MANAGER David Jones
ASSISTANT EDITORS
Bob Treloar AO MiD (military aviation)
John Kindler AO AFC (industry news)
Mike Nelmes (history)

CONTACT

E managing.editor@wingsmagazine.org
W wingsmagazine.org
A RAAFANSW Publications Pty Ltd
Salamander Bay LPO, PO Box 656
Salamander Bay 2317
PRINTED BY: WHO Printing

SUBSCRIPTION

To subscribe for a print copy in the mail or for online access go to wingsmagazine.org

FACEBOOK

Wings on Facebook, go to facebook.com/WingsMagazineRAAFAPublications

air force association

PRESIDENT'S DESK

I CONGRATULATED AIR MARSHAL ROBERT CHIPMAN AM, CSC on his appointment to Chief of Air Force (CAF) and also took the opportunity to visit Air Marshal Mel Hupfeld to thank him for his earnest support to me and the Association during his tenure as CAF. I look forward to a continued relationship with Air Marshal Hupfeld.

At DVA's Ex-Service Organisation (ESO) Round Table, ESO representatives had the opportunity to meet the new Minister for Veterans' Affairs, the Honourable Matt Keogh and the Assistant Minister for Veterans' Affairs, the Honourable Matt Thistlethwaite. The ministers spoke about the government's priorities for veterans, which included additional resources to assist DVA's veteran claims process, funding for veterans' hubs, homelessness, and other wellbeing matters. Although the Veterans' Affairs portfolio is not in the inner-cabinet of government, as was previously the case, it is supported by two ministerial appointments that highlight the government's high priority for veteran matters. I look forward to engaging the ministers who welcome input from the ESOs.

The Royal Commission into Defence and Veteran Suicide has gathered significant momentum. Not surprising, it has reported, among other issues, the difficulties many servicemen and women face transitioning to civilian life. That is especially the case for those suffering varying degrees of mental ill health. Previous Ministers for Veterans' Affairs have advised the Royal Commission of the significant role ESOs play in providing a range of support measures to exiting veterans. ESOs have different resources and experience in providing transition support activities. Veterans and their families are encouraged to contact any ESO to identify the one that can best respond to their needs. ESOs, at the very minimum, have a referral role and can direct an inquiry to an appropriate service provider.

In May, the Air Force Association's National Board approved a new structure for Air Force Association Ltd, the national entity. The new structure will increase members' influence in deciding on and carrying out the Association's veteran support activities, and nominating for election of the major office bearers. AFA Ltd will have a smaller skills-based board that will provide strategic governance for the federated body, with guidance and input from a federation council, comprising representatives from state/territory divisions. The national entity will continue to manage the company and act as the conduit between the Association and outside agencies and government departments such as DVA. While the restructure will not impact on divisions other than for them to decide to formally become part of the Association, it was a watershed event equivalent to the morphing of the Australian Flying Corps Association into an air force association. A new constitution to reflect the restructured entity is being developed.

Wings is now available online through the Defence Protected Network free to all Air Force serving members, an initiative supported by the former CAF. Serving members are encouraged to submit articles to the *Wings* managing editor for inclusion in the magazine. The intention is to increase veteran-related articles in *Wings*.

Keep safe and stay well.

Carl Schiller
National President

THE AUSTRALIAN AIR FORCE ASSOCIATION

NATIONAL PRESIDENT
Carl Schiller OAM, CSM

NATIONAL VICE PRESIDENT
Peter McDermott AM, CSC

NATIONAL SECRETARY
Peter Colliver OAM natsec@raafa.org.au

NATIONAL TREASURER
Robbie Robertson

JOIN THE AIR FORCE ASSOCIATION

To join the Association, visit raafa.org and follow the JOIN US link. For assistance, contact the Association by phone or email. See page 15 for contact details.

EDITED BY Bob Treloar

Air Force welcomes new chief

AIR MARSHAL MEL HUPFELD AO, DSC officially transferred command of the Royal Australian Air Force to Air Marshal Robert Chipman AM, CSC on 1 July.

The formal change of command ceremony took place at Sir Thomas Blamey Square, Russell Offices and included a parade and flypast by several F/A-18F Super Hornet aircraft.

Air Marshal Hupfeld reflected on his time as Chief of Air Force (CAF) and the changes that had taken place during his tenure.

"When I commenced my role as Chief of Air Force, we were in a period of great capability transition – we were bringing on some of the very first F-35A Lightning II jets and EA-18G Growler and P-8A Poseidon aircraft," he said.

"I am most proud of our dedicated and skilled workforce who are trusted to deliver air and space power for the Joint Force, wherever it's needed. Our people are, and continue to be, at the heart of our capability.

Air Marshal Hupfeld's career in Air Force began in January 1980 when he joined as a RAAF Academy cadet. He retires after 42 years of dedicated service.

New CAF, Air Marshal Chipman, expressed his ongoing commitment to the Air Force and the nation. "I extend my gratitude to Air Marshal Hupfeld who has instilled an Air Force culture that prioritises diversity, inclusion and professional mastery of air and space power in support of the Joint Force. I am enthusiastic for my tenure and the journey this appointment will bring."

Air Marshal Chipman joined the Air Force in 1989 and, after qualifying as an aeronautical engineer, served as a fighter pilot. Previously, he was the Head of Military Strategic Commitments, providing strategic military advice, planning guidance and Defence input to the national crisis management machinery.

ABOVE Outgoing CAF Air Marshal Mel Hupfeld, right, presents incoming CAF, Air Marshal Robert Chipman with the original sword worn by Sir Richard Williams, the first Chief of Air Force. Photo: FSGT Kev Berriman.

ADF'S NEWEST PILOTS

STUDENTS FROM NO.265 AUSTRALIAN DEFENCE FORCE PILOTS COURSE received their wings and graduated from No.2 Flying Training School (2FTS) at RAAF Base Pearce, Western Australia in April. The first course to graduate for 2022, the parade was reviewed by Commander of Air Combat Group, Air Commodore Tim Alsop, escorted by Wing Commander Jay Tuffley, Commanding Officer of 2FTS.

Addressing the parade, Air Commodore Alsop acknowledged the fellow centenarian graduates present from No.165 course and the family and friends who had supported the current graduates to achieve their wings.

A solo aerobatic display highlighted the skills learnt during the course while demonstrating the capability of the Pilatus PC-21 aircraft.

LEFT Air Commodore Tim Alsop inspects graduating pilots from No. 265 Pilots' course at RAAF Base Pearce. Photo: Chris Kershaw (Department of Defence).

USAF BUYING WEDGETAILS

THE US AIR FORCE has announced it will replace part of its E-3 Sentry Airborne Early Warning and Control System (AWACS) fleet with 22 Boeing E-7 Wedgetail aircraft. The E-3 Sentry is a heavily modified B-707 aircraft introduced into service in the 1970s; mission capable rates have declined and fleet maintenance has become more difficult. The Wedgetail, developed by Australia for the RAAF is based on the B737-700 series aircraft and has a proven track record on operations in the Middle East and elsewhere.

The decision to purchase the Wedgetail was based on market research that indicated that it is "the only platform" that could meet all the US Defence Department's requirements in time to replace the aging E-3 aircraft.

About half of the US fleet will be retired and the first rapid prototype E-7 is to be delivered in fiscal year 2027.

Source: Defence News

A RAAF E-7A Wedgetail lands at Nellis Air Force Base, Nevada, USA during an exercise in January. Photo: US Air Force.

Next generation JAMMER TRAINING

THE US NAVY (USN) AND RAAF have started a second round of training to improve their interoperability and familiarisation with the AN/ALQ-249 Next Generation Jammer Mid-Band (NGJ-MB) pods. The training event marks a steady build-up of skills in handling and maintaining the system ahead of fielding the jammer pod in the coming years.

The pod replaces the USN's venerable ALQ-99 tactical jamming system, which has been in service since the Vietnam War. The ALQ-99 originally equipped the Navy and Marine EA-6B Prowler and Air Force EF-111 Raven, but today is only used on the EA-18G Growler.

When equipped with the NGJ-MB, the EA-18G will be capable of performing missions such as stand-off/in escort jamming, modified escort jamming, suppression of enemy air defences, signal and electronic intelligence gathering, communications jamming, and supporting the destruction of enemy air defences.

Source: Overt Defence

LEFT Two NGJ mid-band pods, attached to an EA-18G Growler, undergo testing in the Air Combat Environmental Test and Evaluation Facility anechoic chamber at a US Naval Air Station. Photo: US Navy.

RAAF tankers refuel Japanese F-2s

IN APRIL, the RAAF conducted an air-to-air refuelling qualification program with Japanese F-2A fighters performing multiple contacts and refuellings with a RAAF KC-30A tanker over the Sea of Japan. The flight test program came a few months after Australia and Japan finalised a Status of Forces Agreement, known as the Reciprocal Access Agreement, permitting unprecedented levels of collaboration between the two air forces.

Certification of the Japanese F-2A fighters to refuel from RAAF tankers will enable the two countries to expand their defence relationship.

Japan Air Self Defence Force F-2A aircraft are expected to participate in exercise Pitch Black 22 later this year, allowing them to employ the new capability in a realistic training environment.

Source: Overseas Defence

ABOVE An air-to-air refuelling flight test between a RAAF No.33 Squadron KC-30A Multi-Role Tanker Transport aircraft and a Japan Air Self-Defence Force Mitsubishi F-2A over Japan. Photo: Department of Defence.

$2.5bn for Navy HELICOPTERS

IN A CONTRACT VALUED AT MORE THAN $2.5 BILLION, the Navy's maritime helicopter fleet will obtain an additional 13 MH-60R Romeos (including a replacement for the Romeo lost in 2021). Up to $360 million will be provided to expand facilities at HMAS Albatross to house the expanded fleet, which will replace the Navy's existing Taipan fleet of helicopters.

The Romeo is a next generation submarine hunter and anti-surface warfare helicopter. It can also assist with search and rescue and transport as they have done during recent bushfires and floods.

A further $5.5 billion will cover the acquisition and operation of 29 AH-64E Apache helicopters to replace the Army's existing Tiger helicopters, with an additional investment of up to $500 million provided to upgrade facilities to support the new Apaches.

The Apache is a proven and reliable attack helicopter which is operated by United States and British forces. It has improved sensors, communications and networking systems, attack capabilities and enhanced survivability.

Both helicopter types are expected to commence delivery in 2025.

Source: Australian Defence Media

ABOVE An MH-60R Romeo helicopter from No.816 Squadron firing an Advance Precision Kill Weapons System laser guided rocket off the South Coast of NSW. Photo: CPOIS Cameron Martin.

Defence orders seven more GHOST BATS

A Ghost Bat test flight from the Woomera Range Complex, South Australia. Photo: CPL Craig Barrett.

AN ADDITIONAL $454 MILLION INVESTMENT in the Loyal Wingman program will deliver seven uncrewed autonomous aerial vehicles, MQ-28A Ghost Bats, to the RAAF within the next two years, bringing the total fleet to 10.

The MQ-28A aircraft's first flight was in February 2021, two years and three months from the commencement of the project. A second aircraft has joined the flight test program and a third is being readied for flight test later this year.

The first Australian-built military combat aircraft in 50 years, the MQ-28A was designed, manufactured and flown in a four-year joint partnership between the RAAF and Boeing Defence Australia. More than 70 percent of each aircraft is designed, sourced and manufactured in Australia.

It is expected to enter service with the RAAF in 2024-25, providing a world-leading airborne system that will team with existing manned air combat aircraft and conduct air combat, reconnaissance and surveillance missions. By sharing technology and leveraging the expertise of US partners, the MQ-28A aircraft will be interoperable with Australia's allies and partners in the Indo-Pacific region.

Source: Australian Defence Media

RAAF to receive first MC-55A IN 2023

THE RAAF EXPECTS to take delivery of the first of four MC-55A Peregrine aircraft in 2023, with initial operational capability (IOC) to follow in 2024. IOC is contingent upon the aircraft successfully completing ground tests, flight tests, and a range of training activities.

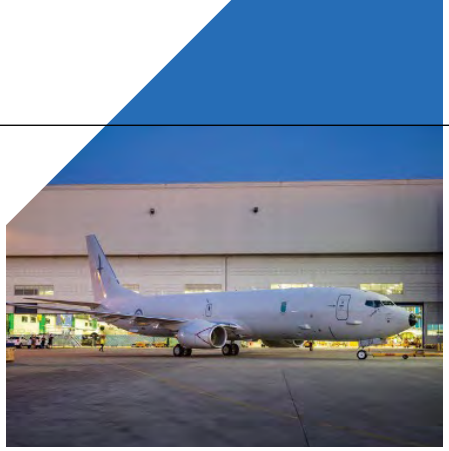
All four aircraft are in varying stages of the modification cycle, and initial flight test activities to demonstrate that the modified G550 aircraft satisfies ADF airworthiness requirements have commenced.

The MC-55A Peregrine procurement includes four aircraft, air, ground and support mission systems, facilities, information communication technology, training devices, and sustainment. The Peregrine will provide a support role for the Lockheed Martin F-35A, Boeing EA-18G Growler, and E-7 Wedgetail airborne early warning and control aircraft.

A key enabler for the fifth-generation force, the MC-55A will provide full spectrum intelligence, surveillance, reconnaissance and electronic warfare capabilities, and will support a range of flexible mission roles for Defence. The capability will substantially enhance electronic warfare support for naval, air and land force operations in the electromagnetic environment.

Source: Flight Global

LEFT Artist rendering of MC-55A Peregrine. Image: L3Harris.



P-8A Poseidons for NZ Air Force

BOEING ROLLED OUT the first of four P-8A Poseidon maritime patrol aircraft in a Royal New Zealand Air Force (RNZAF) livery at its factory in Renton, Washington State in July. Designed for anti-submarine and anti-surface ship warfare, along with surveillance, reconnaissance and intelligence roles, the P-8 is currently in operation with the Indian Navy, the RAAF and the Royal Air Force.

The plane, a heavily modified variant of the Boeing 737 passenger aircraft, features the RNZAF's Kiwi roundel with the Albatross mascot of the RNZAF's No.5 Squadron emblazoned on the tail.

The P-8s will replace six ageing P-3K Orions, with the first to be delivered to the NZ Ministry of Defence in December and the next three in 2023.

Source: NZ Herald.

Chinese jet intercepts Poseidon

DURING A ROUTINE MARITIME SURVEILLANCE MISSION in international airspace over the South China Sea region, a RAAF P-8 Poseidon maritime surveillance aircraft was intercepted by a Chinese J-16 fighter aircraft.

The intercept on 26 May resulted in a dangerous manoeuvre which threatened the P-8 and its crew. The Chinese aircraft flew very close in front of the P-8 aircraft and released a "bundle of chaff", small slivers of aluminium that were ingested into the Australian aircraft's engine.

Defence has for decades undertaken maritime surveillance activities in the region and does so in accordance with international law, exercising the right to freedom of navigation and overflight in international waters and airspace.

A second Australian P-8A Poseidon was dispatched over contested waters in the South China Sea just hours after the intercept.

Defence declined to discuss the 26 May incident, but flight data obtained by the ABC indicated some details of the flight and other recent ADF maritime surveillance missions flown from Clark Air Base in the Philippines. The RAAF had two P-8A Poseidons deployed to Clark Air Base to conduct intelligence collection activities over the South China Sea, and to assist the Philippines Government with the fight against Islamic State.

Poseidon aircraft continued to conduct surveillance flights before being deployed to India on 8 June for joint maritime surveillance activities with the Indian Navy.

Source: Department of Defence; ABC.

ABOVE Shenyang J-16.

ABOVE RAAF P-8 Poseidon.

RAAF and USAF C-17 Globemaster III fly in formation during an aerial maneuver training mission around the Hawaiian islands as part of Exercise Global Dexterity 2022. Photo: Airman 1st Class Makensie Cooper.

AIR FORCES SWAP SEATS

IN MAY, C-17 GLOBEMASTER III CREWMEMBERS from the RAAF and US Air Force (USAF) shared aircraft as they carried out a series of airdrop and airlift operations, validating the effectiveness of bilateral aircrew performance from partnered nations.

Exercise Global Dexterity 2022 was permitted through an international 'Interfly Agreement', established during an Aerospace Medical Association Conference in 2012, intended to promote and support cooperation and interoperability between the two nations.

Before take-off for each mission, maintenance teams from both nations serviced each other's aircraft and bilateral intelligence specialists worked together to develop robust tactical scenarios to engage the crews during the exercise.

Aircrew members used the Hawaii Air National Guard's 169th Air Defence Squadron to run real-time scenario scripts, creating layers of complexity and dynamic-threat exposure while flying through the Haiwaian island chain. Each training mission consisted of a mixture of unfamiliar crew members allocated across three aircraft – two USAF and one RAAF. For some flights US and Australian pilots flew side-by-side in the same cockpit. Other flights entailed one country's air force covering the loadmaster positions in the rear while their bilateral partners flew in the front.

RAAF operations with Indian Navy

A LONG-RANGE RAAF MARITIME SURVEILLANCE Boeing P-8A aircraft operated from INS Hansa, Goa on a three-day exercise in June with the Indian Navy. Coordinated operations included anti-submarine warfare and surface surveillance.

India and Australia are members of the quadrilateral security dialogue, known as the Quad, a strategic security dialogue between Australia, India, Japan and the United States that aims at an open Indo-Pacific region.

In April, the Indian Navy deployed a P-8I aircraft to Darwin for similar coordinated operations in northern Australian waters.

Indian and Australian P8 aircraft have been regularly undertaking coordinated operations as part of various bilateral and multilateral naval warfare exercises.

Source: India Today

ABOVE RAAF and Indian Navy crews.

Aborted TAKE-OFF INCIDENT

IN DECEMBER 2020, a RAAF F/A-18F Super Hornet veered off the runway at Amberley during the take-off roll forcing the crew to eject.

The results of the safety investigation conducted by the Defence Flight Safety Bureau indicated it was pilot error. Investigators found that substandard adherence to checklist actions prior to the aircraft entering the runway resulted in a master caution and check trim message on the digital display indicator as afterburner was selected.

The warning lights distracted the pilot who lost directional control of the aircraft. The Weapons System Officer intitited the ejection as the aircraft left the runway. The crew received minor injuries from the ejection and the aircraft was damaged.

During a hearing at the Australian Senate in April 2022, the Deputy Chief of Air Force stated that the aircraft had been returned to service after repairs costing $1.5m.

Source: Aerotime Hub

An F/A-18F Super Hornet conducts a low fly past of RAAF Base Amberley during Exercise Dawn Strike 22. Photo: LACW Emma Schwenke.

ABOVE Commander Air Combat Group, Air Commodore Timothy Alsop (right) presents Squadron Leader Daniel Grealy with an oversized replica patch on attaining 4,000 flying hours in F/A-18 type aircraft.

F/A-18 milestone

IN A FIRST FOR THE RAAF, No.82 Wing fighter pilot Squadron Leader Daniel Grealy has flown 4,000 hours in F/A-18 aircraft. The milestone, achieved on 23 May at RAAF Base Amberley, includes 1,500 hours in F/A-18A/B Hornets and 2,500 hours in F/A-18F Super Hornets.

With more than 27 years of experience in fast-jet aviation, Squadron Leader Grealy has flown tours in Australia and overseas during both peacetime and war-like operations. He flew the F/A-18A/B Hornet from 1995, both as a fighter combat instructor and flight commander. Posted to Initial Cadre Super Hornet in 2009, he conducted instructional duties with the US Navy before returning to No.82 Wing as No.1 Squadron Executive Officer. He is currently Specialist Aircrew at No.82 Wing Training Flight flying the F/A-18F Super Hornet.

Source: Aviation Geek Club

FREE FALLING IN WAGGA

COMBAT CONTROLLERS OF NO.4 SQUADRON conducted their annual parachute continuation training, Exercise Havoc Drop 20-1, at RAAF Base Wagga in July. The training exercise tests the abilities and proficiencies of combat control teams in core airpower roles, and an intensive training continuum allows the team to work with precision under pressure.

The exercise developed controllers' parachute insertion techniques to enable them to land at unfamiliar drop zones as part of a team, day or night. Jumps were conducted from 8,000 to 10,000 feet using military free-fall and static-line parachute techniques. The challenging part of the jump is the form up under a canopy glide to land in the drop zone together.

Exercise Havoc Drop was supported by a C130J Hercules from No.37 Squadron and jump masters and parachute riggers from the Army's 176 Air Dispatch Squadron.

Source: Department of Defence

ABOVE A combat controller of No.4 Squadron jumps off the ramp of a C-130J Hercules for a training mission during Exercise Havoc Drop at RAAF Base Wagga. Photo: Corporal Dan Pinhorn.

HONOURING BOMBER COMMAND

ON 2 JUNE, the Air Force Association (South Australia) partnered with RAAF Edinburgh to host the 2022 Bomber Command Commemorative Service in Adelaide. The service honoured the more than 3,000 Australian aviators who paid the ultimate sacrifice in one of World War II's most costly campaigns. It also highlighted the 80th anniversary of a number of events: the 1,000 aircraft bomber raids, the formations of 462SQN and 467SQN, the first operational use of the Lancaster Bomber and the death of FSGT Hugh Brodie, the air observer who authored the poem *An Airman's Prayer* and who was killed in action in the early hours of 3 June 1942 when his Wellington aircraft was shot down.

WGCDR Duncan Scott, CO 462SQN (a Bomber Command unit) provided the keynote address, noting the 80th anniversaries and the sacrifices Bomber Command aviators made. Nikki King, daughter of SQNLDR Dave Shannon (DSO and Bar, DFC and Bar) read *An Airman's Prayer* and Rod Bunten, partner of the Governor of South Australia read a letter FSGT Brodie wrote to his pupils, which was found in his personal belongings after his death. Mr Bunten, a former teacher like FSGT Brodie, is the son of a Bomber Command tail wireless operator air gunner, making his reading of the letter particularly special.

Four South Australian Bomber Command veterans attended: FLGOFF Ray Merrill DFC, FLGOFF Angas Hughes, FLGOFF Don Looker and SGT John Underhill (RAF).

The poignant ceremony was both a solemn acknowledgement of those who served and fell and a celebration of those who survived and were able to join with today's young veterans and aviators over refreshments after the service.

ABOVE Bomber Command veteran SGT John Underhill (RAF) with two serving RAAF aviators from 462SQN.

Bomber Command veterans, from left, SGT John Underhil, FLGOFF Don Looker, FLGOFF Ray Merrill DFC, and FLGOFF Angas Hughes, with Her Excellency The Honourable Frances Adamson AC, Governor of South Australia, Dr Robert Black, President AFA-SA and RAAF senior Officers.

Remembering a distinguised AVIATOR

SIR ROSS MACPHERSON SMITH KBE, MC and Bar, DFC and two Bars AFC is one of Australia's most decorated military aviators and a world aviation pioneer.

Serving on the ground with the AIF at Gallipoli and the Battle of Romani and in the air during World War I, he was the most successful Australian air ace in the Middle East. Only two years after learning how to fly, the daring aviator led an intrepid team of airmen comprising himself, his brother Sir Keith Smith, and air mechanics Wally Shiers and Jim Bennett to be the first to fly from England to Australia to win the 1919 Great Air Race. They were lauded as national heroes. Across the globe, Sir Ross Smith was declared the greatest airman of the time.

Tragically, two years later, Ross Smith and his mechanic Jim Bennett were killed in an aircraft crash in England while preparing for the first ever aerial circumnavigation of the world. Their bodies were returned to Australia. Sir Ross Smith was laid in state at St Peters Cathedral in Adelaide before his funeral on 15 June 1922. The funeral procession to North Road Cemetery brought the city to a standstill as 100,000 people, a fifth of Adelaide's population at the time, lined the streets to pay their respects.

On the 15 June 2022, the Air Force Association (SA) partnered with RAAF Edinburgh and the History Trust of SA to honour the distinguished aviator on the 100th anniversary of his funeral. In the morning, a simple acknowledgement was held at Sir Ross Smith's grave where a wreath and rosemary were laid and *The Ode* was recited by AFA-SA President Dr Robert Black AM.

A commemorative service followed at St Peter's Cathedral with representatives from across the Adelaide community. A catafalque party of RAAF and Army Light Horse officers carrying swords was mounted around a memorial comprising two swords, Sir Ross Smith's medals, a leather flying helmet and a statue of the aviator. Australian Air Force Cadets formed an honour guard around the congregation.

GPCAPT Andrew Figtree, acting Senior Air Force Representative, provided the keynote address which highlighted the daring, initiative and airmanship of Sir Ross Smith. Greg Mackie, chief executive of the History Trust of SA, recited the poem *The Late Sir Ross Smith – Napoleon of the Air*.

Minister for Veterans Affairs Geoff Brock laid a wreath on behalf of the people of South Australia and GPCAPT Figtree laid a wreath on behalf of the ADF. Dr Black recited *The Ode* and a bugler from the Air Force Band sounded *Last Post* from high in the gallery.

ABOVE The catafalque party at post while GPCAPT Figtree provides the keynote address at the Sir Ross Smith commemorative service.

BELOW LEFT AFA-SA President Dr Robert Black recites *The Ode* at the Sir Ross Smith graveside acknowledgement.

ABOVE Two swords lie in front of a statue of Sir Ross Smith and his medals with the Australian National Flag and the RAAF Ensign in the background.

A voice to government for members and ex-members

An association for all ranks

Open to citizens with a strong aviation interest

WINGS magazine provided free to members

Air Force Association

Supporting veterans | Fostering friendships | Honouring our legacy

NEW SOUTH WALES
Air Force Association (NSW Division)
PO Box 494,
Paddington NSW 2021
Tel: 0401 154 154 | secretary@raafansw.org.au
www.raafansw.org.au

AUSTRALIAN CAPITAL TERRITORY
RAAF Association (ACT Division)
PO Box 111,
CAMPBELL ACT 2612
Tel: 0439 476 742 | ACTTreas@raafaact.org.au
www.raafaact.org.au

VICTORIA
Air Force Association (Victoria Division)
24 Camberwell Rd, HAWTHORN EAST VIC 3123
Tel: 03 9813 4600 | office@afavic.org.au
www.raafavic.org.au

QUEENSLAND
RAAF Association (QLD Division)
PO Box 2259, WELLINGTON POINT QLD 4160
Mob: 0419 688 014 | statesec@raafaqld.org
www.raafaqld.com

SOUTH AUSTRALIA
RAAF Association (SA Division)
Torrens Parade Ground Victoria Dr, ADELAIDE SA 5000
Tel: 08 8227 0980 | raafaad@internode.on.net
www.raafasa.org.au

WESTERN AUSTRALIA
RAAFA (WA Division)
18 Bowman St,
SOUTH PERTH WA 6151
Tel: 08 9288 8400 | enquiries@raafawa.org.au
www.raafawa.org.au

TASMANIA
RAAF Association (TAS Division)
RAAF Memorial Centre,
61 Davey St, HOBART 7000
Tel: 03 6200 9221 | secretary@raafatas.org.au
www.raafatas.com

Tornado GR4 lands at BULL CREEK MUSEUM

Panavia Tornado GR4 ZG791 at RAF Marham, Norfolk, UK, February 2019. Photo: RAF.

THE ONLY TORNADO GR4 on display outside of the UK has been unveiled at the Aviation Heritage Museum, Bull Creek, Perth, Western Australia.

The Panavia Tornado GR4 Strike Aircraft could fly at a top speed of 2,400kph and to an altitude of 15,000m and could also perform well at low levels and low speeds thanks to its variable sweep wing. After an impressive career the Tornado GR4 was retired from service by the Royal Air Force (RAF) in 2019.

Ian Craig, Head of Clear Skies at the RAAF Association (RAAFA) WA which oversees the museum, says the organisation began applying to get the aircraft three years ago.

"It was a piece of aviation history we had to take a shot at getting for our museum," he said. "We already have a Spitfire and a Lancaster which show the close relationship between RAAF and RAF so the Tornado GR4 felt like the next important piece of the puzzle. To our delight the RAF saw the value in having one in Australia."

Head of heritage and stories for the RAF, Wing Commander Erica Ferguson says it was an easy decision to choose the RAAFA museum from the 63 applications she received for the decommissioned aircraft.

"When I saw how great the stories already being told out at Bull Creek were and how amazingly skilled and dedicated the volunteers and staff were there, it was quite an easy choice to make," she says.

Panavia Tornado ZG791 was disassembled and left the UK in January by sea. The aircraft arrived in Perth about six weeks later and Wing Commander Ferguson brought a team of six RAF technicians to reassemble it. "She's a complicated aircraft because she has swing wings, wings that can go backwards to increase the speed," she says.

Although the Tornado GR4 wasn't flown by the RAAF, many RAAF air and ground crew flew or worked on them overseas.

"We have also discovered a large community of ex-RAF members who have made a home in Perth and Australia who

ABOVE The Tornado GR4 at the Aviation Heritage Museum. Photo: Aviation Heritage Museum.

RAF Wing Commander Erica Ferguson and Ian Craig with the RAF crew that reassembled ZG791. Photo: Aviation Heritage Museum.

have a special connection to the Tornado, so it is so exciting to be able to bring that community together around the aircraft," says Ian.

Squadron Leader Martin Keer RAAF flew Tornado ZG791 in 2001. "It is indeed a bizarre coincidence given my five years as an instructor on 79SQN at RAAF Base Pearce, my flights in RAAF F-111C/Gs, and as a Roulette pilot that of all the Tornado GR4 aircraft to be gifted to the Bull Creek museum, it is the aircraft in which I came the closest to hostile fire," says Martin.

"I first flew ZG791 on 13 June 2001, exactly 21 years prior to the start of her rebuild in WA. My navigator for that sortie was FLTLT Sally Willers, one of the few female RAF navigators serving at the time. The sortie involved flying cover for our element lead during a four-ship sortie over Iraq from Ali Al Salem Air Base in Kuwait.

"The hostile fire sortie occurred on 3 July 2001 during an operational mission with my navigator FLTLT Crispin Hilton. Roughly halfway through our patrol we were engaged by multiple Iraqi anti-aircraft artillery (AAA) batteries. Numerous rounds from KS-19 and S-60 artillery pieces exploded around us. I had been looking over the right wing when Cris shouted 'AAA out left!'. I engaged the afterburner and took immediate evasive action aggressively raising the nose to take ZG791 away from the targeted height block.

"My fifth and final sortie in ZG791, my first operational four-ship lead mission, was flown with navigator FLTLT Jonny Meadows on 21 July 2001. A nerve-racking but enormously rewarding mission. Throughout our operational deployment ZG791 kept us safe."

The Tornado GR4 was dismantled and loaded onto a cargo ship to come to Australia. Photo: Wing Commander Erica Ferguson.

Ad Astra Aviator
PODCASTS

AN INITIATIVE BY AFA NATIONAL AND AFA NSW CAPTURES the personal recollections and experiences of both retired and serving Air Force personnel in a series of podcasts. The project, managed by Peter Ring, has recorded more than 50 individual stories at the time of publication. Here are three excerpts to whet your interest.

RAY SEAVER: KOREAN WAR FIGHTER PILOT

Ray was posted to 77 Squadron, Korea on twin-engine Meteors. At that stage, he had less than 300 hours flight time and felt Aero Club pilots had more experience. "The new arrivals were mostly only about 21 years old and were there to learn the art of war though interdiction. We had very little knowledge of why we were in Korea. We had all lived sheltered lives and here we were fighting a war.

"We either bombed, rocketed or strafed – all very challenging for novice pilots. If they were shooting at us in the dive, we could see the 'golf balls' going past us, hopefully. Enemy aircraft were sometimes a problem that needed good tactics to survive. Crashes and deaths were a fact of life but people in 77SQN just kept getting on with it."

Listen to Ray's story to share his experiences as a young fighter pilot operating in Korea during the 1950s.

AIR VICE-MARSHAL JOE 'VINNY' IERVASI AM, CSC: RECENT AIR COMMANDER AUSTRALIA

During his Air Force career as a fighter pilot, Joe accrued more than 3,000 hours flying fast jets. A notable posting was on exchange to No.5 Squadron RAF flying the Tornado F3, during which he deployed on Operation Deny Flight enforcing the no-fly zone over Bosnia-Herzegovina (1995) to help quell the Balkans war.

In staff and command appointments, Air Vice Marshal Iervasi served with Capability Systems, 81 Wing as Senior Operations Officer and Officer Commanding, and Chief of Staff positions to Air Combat Group and to the Vice Chief of the Defence Force. In December 2018, on promotion to Air Vice-Marshal, he was appointed Commander Joint Task Force 633 and deployed again to the Middle East, stationed in Al Minhad Air Base, Dubai. Listen to his Podcast to glean a personal view of an active career in the modern Air Force.

PETER ARMSTRONG: HUEY'S IN VIETNAM

The Australian Air Force needs personnel who can adapt to whatever demanding operations they are chosen for. Peter Armstrong and his mate Peter Bradford, who features in a fellow podcast, represent the best in pilots who were chosen to fly many different aeroplane types and excelled at the task.

In the podcast, Peter describes his life flying Iroquois helicopters in Vietnam where the sound of the Huey was not only welcome but, on occasions for troops on the ground, the difference between life and death.

Peter also relates his time flying C130 Hercules, fast-jet instruction, Boeing 707s and DC8s for Qantas.

Scan the QR code to access the podcast website or go to raafansw.org.au/podcasts.

AVALON 2023

AUSTRALIAN INTERNATIONAL AIRSHOW

AEROSPACE AND DEFENCE EXPOSITION

Act now to secure your company's place at Australia's own international industry event, the most comprehensive aviation, aerospace and defence exposition in the Southern Hemisphere.

28 FEBRUARY - 5 MARCH 2023

AVALON 2019 Highlights

- 38,952 Trade Visitor Attendances
- 698 Participating Companies
- 41 International Air Chiefs and Representatives
- 161 Official Delegations

www.airshow.com.au
Contact the AVALON 2023 Sales Team
T: + 61 (0) 3 5282 0500
E: expo@amda.com.au
AVALON AIRPORT, GEELONG, VICTORIA

AMDA FOUNDATION LIMITED

VICTORIA State Government Australia

CITY OF GREATER GEELONG

Official Logistics Provider
DB SCHENKER

EDITED BY John Kindler

NASC UNVEILS NEW LOW-COST UAV

NAVMAR APPLIED SCIENCES CORPORATION (NASC) has unveiled its new multirole, dual jet engine unmanned aerial vehicle (UAV), the NASC Tracer.

Developed from a modified version of Sonex Aicraft's SubSonex airframe, it is designed to provide a low-cost alternative for manned-unmanned teaming operations, counter-unmanned aerial-systems missions, reconnaissance, communications and electronic warfare. It has a wingspan 5.5m and weighs 680kg, enabling the platform to carry a range of payloads.

Closer to home, the UAV race has heated up. In March, Hypersonix Launch Systems, the University of Southern Queensland (USQ), LSM Advanced Composites and Romar Engineering were awarded a grant via the federal government's Cooperative Research Centres Project to help develop a reusable UAV that can travel up to Mach 12. The group is expected to develop a UAV powered by a Spartan hydrogen scramjet engine.

According to USQ, the engine uses oxygen from the surrounding atmosphere, and that will reduce the UAV's weight by 60 percent. Creating new materials to withstand the immense heat will permit the UAV to be reused.

Source: Defence Connect

SECURE COMMUNICATIONS

NORTHROP GRUMMAN AUSTRALIA has partnered with Queensland-based electronics engineering company IntelliDesign to manufacture a secure communications solution (SCS) device.

The SCS-200 device, comprising hardware originally designed by IntelliDesign and operating programs developed by Northrop Grumman, is billed as a sovereign solution designed to deliver simple, secure network access for deployed teams and individuals across key organisations, including the Department of Defence and Department of Home Affairs. It is to be manufactured at IntelliDesign's plant at Seventeen Mile Rocks, Qld with initial delivery to government agencies scheduled for 2023.

The SCS-200 capability is tipped to integrate high-speed, low-latency and cyber-security protection of private 5G networks, while also supporting Joint All-Domain Command and Control architecture.

The partnership involves the establishment of a joint research and development framework to prototype, demonstrate and test AT&T's commercial 5G networking capabilities integrated with Northrop Grumman mission systems.

Source: Defence Connect

Australian SME export success

MELBOURNE-BASED SECURE COMMUNICATIONS COMPANY C4i reportedly achieved $33.6 million in defence export orders in 2021, the largest value of export orders in its history.

C4i delivers high-tech secure communication system technology to prime contractors and international end-user customers including the US Air Force and Marine Corps, UK Ministry of Defence, Canadian Department of National Defence, Taiwan Airforce and the Qatar Ministry of Defense. In the Australian Defence market, a C4i secure Voice Communication System is being rolled out in the Air Defence segment of the RAAF.

Source: Australian Defence Magazine

SENTIENT VISION WINS $2M GRANT

ABOVE Sentient Vision Systems ViDAR-equipped DA 42 Aircraft.

MELBOURNE ARTIFICIAL INTELLIGENCE (AI) COMPANY Sentient Vision Systems has won a $2.1 million Australian Government grant to establish a sovereign in-house manufacturing facility for its ViDAR (visual detection and ranging) search and surveillance pod.

The grant will enable volume manufacture in Australia of the company's ViDAR pods for local and export customers.

ViDAR, the world's first passive optical radar, has application for search and rescue, wide area surveillance, border security and law enforcement operations. It uses AI to scan every pixel in every frame of an optical sensor's imagery feed to detect objects invisible to a human operator, at sea or over land. When it detects an object, the ViDAR software places a thumbnail on the Mission Management System screen so the operator can examine the object in more detail. The sensor can be mounted on crewed and uncrewed fixed and rotary winged platforms.

Funding to monitor satellites from space

THE NSW GOVERNMENT has allocated $500,000 in funding to cutting-edge technology that will monitor low-earth orbit satellites from space. Typically, satellites are monitored from ground stations, such as those at the Canberra Deep Space Communication Complex, and at Woomera, South Australia. The funding will advance technology that is hoped to take rapid and accurate imaging of satellites in low-Earth orbit, images that are often difficult to capture from the ground due to satellites' speed.

Commercial companies, such as LeoLabs Australia which tracks activity in orbit in the Southern Hemisphere, also provide that type of service for the space industry. Director of the Defence Innovation Network (DIN) Professor Bradley Williams said the funding will support the initiative's work to secure access to space and achieve real-time awareness of small and large satellites in orbit.

The NSW DIN is a university-led initiative of the state government and the Defence Science and Technology Group to grow the industry through collaboration with academia.

BAE SYSTEMS JOINS TRAILBLAZER

BAE SYSTEMS AUSTRALIA has joined the new Defence Trailblazer Concept of the Sovereign Capability program which is being led by the Universities of Adelaide and New South Wales.

A $50 million commitment in government funds for the Trailblazer program is designed to bring universities and industry together to solve some of Australia's most significant defence technology challenges and fast-track the development of new products and technologies, with a focus on autonomous operations, hypersonics and high-frequency radio wave applications.

BAE Systems will contribute to Trailblazer through its national Red Ochre Labs research and development centre, which employs more than 500 people across Australia.

Source: Australian Defence Magazine

New Australian AIRSHOW

AN ALL-NEW Australian airshow will be held on Queensland's Gold Coast next year.The Pacific Airshow Gold Coast show, a sister event to the Pacific Airshow, held at Huntington Beach in California will be staged in August 2023. The waterfront airshow featuring both civil and military aircraft is planned to be an annual event.

The timing of the airshow is aligned with the conclusion of Exercise Talisman Sabre and the beginning of Exercise Pitch-Black biennial exercises, and organisers hope to leverage participation from assets that will be already in-country. The US military has given positive indications of support.

The Pacific Airshow is the only event in the USA to win the US Air Force Show Site of the Year, in 2018 and 2019. The 2021 event was seen by more than three million people.

Source: Australian Defence Magazine


The Arnhem Space Centre.

Australia's ELA launches THREE NASA ROCKETS

ON 11 JULY, EQUATORIAL LAUNCH AUSTRALIA (ELA) successfully completed its third NASA commercial rocket launch in 15 days. The Northern Territory-based launch company sent NASA's first commercial rocket into space on 26 June with two more launches in July.

The contract to launch three scientific research rockets for NASA was announced in 2019, and initially planned for lift-off in 2020, but was delayed due to pandemic-related restrictions.

The three sub-orbital sounding rockets launched from ELA's Arnhem Space Centre on the Dhupuma Plateau near Nhulunbuy, NT are carrying scientific instruments as part of the NASA DEUCE mission which will help astronomers measure an unstudied segment of Centauri A and B's ultraviolet light spectrum, helping them to model stars and understand their effects on planetary atmospheres.

ELA CEO Michael Jones said the successful launch was a great finale to the NASA campaign. "We are really proud to have achieved a very rare feat – three successful launches in just 15 days," he said. "Even more so given the challenging wind conditions."

"The missions with NASA have been an incredible chance to prove the capabilities of our team and facility and we are looking forward to welcoming more partners to the site."

Drone surveillance TRIALS AT SYDNEY AIRPORT

THALES HAS BEEN SELECTED BY AIRSERVICES AUSTRALIA as the primary systems integrator for an Integrated Drone Surveillance System (IDSS) trial at Sydney's Kingsford Airport. The IDSS exploits an array of sensors and C2 systems to generate a 3D holographic radar image of potential drone threats and has been used by airports in the United Kingdom, Asia and the Pacific to detect all sizes of drones. It is expected that the system will also be able to locate the drone's pilot.

Source: Defence Connect

Sea 129 Phase 5 moves to next phase

DEFENCE HAS SELECTED the Schiebel S-100 Camcopter unmanned aerial vehicle (UAV) to satisfy Block One, Phase 5 of Project Sea 129, a $1.3 billion three-block maritime UAV aircraft systems program for the Royal Australian Navy. Phase 5 is the first phase of a 30-year continuous improvement program to provide unmanned intelligence, surveillance, reconnaissance and targeting capabilities, with five-year rolling block upgrades that will incorporate new technology.

Proposed by Raytheon Australia teaming with Schiebel Pacific, the S-100 was chosen for single source consideration without an open tender from five short-listed contenders. The design, development, manufacture, integration and support of the system will all be undertaken in Australia.

Source: Australian Defence Magazine

ABOVE Schiebel S-100 Camcopter.

ANTI-RADIATION MISSILES

AN AUSTRALIAN PROPOSAL to acquire a stock of Northrop Grumman-built anti-radiation missiles has been approved by the US State Department. The Defense Security Cooperation Agency has endorsed a US$94 million (A$135.7 million) foreign military sale of advanced precision strike capability to Australia. The sale will deliver 15 AGM-88E2 Advanced Anti-Radiation Guided Missiles together with training and support services.

The Northrop Grumman-built missiles deployed by strike fighters are designed to provide a combination of precision, survivability and lethality, and are reportedly capable of rapidly engaging land and sea-based air-defence threats, as well as striking time-sensitive targets. Specifically, the missile can destroy or suppress air defence radar systems.

Allectum wins RAAF support contract

CANBERRA-BASED COMPANY ALLECTUM has been selected to provide the sustainment office capability for Distributed Ground Station – Australia, a first-of-type capability for intelligence fusion and dissemination of airborne-generated sensor data for the RAAF.

To service the capability, Allectum employs a diverse range of veterans who will impart their years of service and knowledge of ADF information and communication technology environments to support the RAAF's fifth-generation platforms and key decision-makers.

Allectum, a veteran-owned and operated company, partnered with SME Gateway to win the contract to provide the sustainment office capability.

Source: Australian Defence Magazine

Sixth-generation
USAF FIGHTER

THE US AIR FORCE'S sixth generation fighter platform has entered the engineering, manufacturing and development phase.

It was reported in 2020 that the service has flown a full-scale prototype aircraft. USAF's former top acquisition official, Will Roper, said at the time: "We've already built and flown a full-scale flight demonstrator in the real world, and we broke records in doing it. We are ready to go and build the next-generation aircraft in a way that has never happened before."

Little is known about the aircraft, but the Air Force published concept art in a USAF biennial acquisition report. The report said: "Next Generation Air Dominance is a family of capabilities that enable air superiority in the most challenging operational environments by enforcing the development pillars of digital engineering, agile software development, and open architectures. By executing shorter technology development cycles, the program matures technology and reduces risk through prototyping and operational experimentation.

"The program uses a non-traditional acquisition approach to avoid traditional monolithic program schedules and exorbitant life-cycle sustainment costs. This strategy, called the Digital Century Series approach, creates a realistic business case for industry to adopt commercial best practises for key design activities – before a part is even manufactured."

Source: Aerospace Manufacturing

ABOVE A screenshot of a Northrop Grumman promotion featuring a sixth-generation fighter design not currently in development

LONG-RANGE RADAR PRODUCTION

LOCKHEED MARTIN has completed production of its first AN/TPY-4 radar, which was recently selected by the USAF for the Three-Dimensional Expeditionary Long-Range Radar (3DELRR) Rapid Prototyping program.

TPY-4, which is internationally available, is designed to operate in contested radio frequency environments, leveraging software-defined sensor architecture to enable the radar to quickly adjust to evolving threats and mission requirements.

Other features of the TPY-4 include:

- detection of small, hard-to-detect next-generation threats in heavy clutter
- enabling radar operators to quickly pivot from one mission to another, addressing threats in a contested environment
- fully digital system with operation and performance-defined software enabling quick upgrades to combat emerging threats
- availability in both fixed and transportable variants able to be transported via C-130, C-17, truck, rail, or helicopter.

The completion of production comes just a month after the USAF selected the TPY-4 radar for the 3DELRR program, which includes production options for 35 long-range radar systems.

USAF awards stand-in attack WEAPON CONTRACTS

THE PENTAGON HAS tasked three global defence primes with developing the next-generation air-to-surface missile for the US Air Force's strike fighter fleet.

Lockheed Martin, L3Harris, and Northrop Grumman Corporation have reportedly secured contracts from the USAF for the development of the stand-in attack weapon (SiAW). The contracts have a performance period of three months, with three competitive gates for the selected contractors to validate their missile capabilities under a digital acquisition approach.

As part of Phase 1 of the SiAW competition, the USAF aims to align the SiAW missile system technical capabilities to the Air Combat Command requirements and to the Air Force Weapon Government Reference Architecture. That includes establishing an integrated digital environment to design, develop, and test the initial increment of the SiAW missile system.

The system leverages a digital engineering methodology and model-based systems engineering best practices.

Lockheed Martin and Penten join forces

LOCKHEED MARTIN AUSTRALIA (LMA) has engaged the support of Penten, a Canberra based cyber technology business, for delivery of advanced cyber security capabilities in its bid for the RAAF's Joint Air Battle Management Systems (BMS) to satisfy Project AIR6500-1.

The project aims to deliver a BMS designed to enable the ADF's future Integrated Air and Missile Defence capability to provide greater situational awareness and defence against current and emerging air and missile threats.

Penten has agreed to support the investigation and design of a cyber security framework to mitigate system interception and interference risk ahead of the transition into the AIR6500-1 acquisition phase.

The cyber security technologies will be designed to focus on sovereign secure mobility, tactical communications security, cyber deception, cryptography and applied artificial intelligence and machine learning. Those capabilities are expected to help detect, track and mitigate cyber threats, while also reinforcing the security of LMA's open systems architecture program solution.

Source: Defence Connect

BAE chief information and digital officer

BAE SYSTEMS AUSTRALIA has announced the appointment of Michael Salas as the company's new Chief Information and Digital Officer.

Salas was previously the Chief Information and Digital Officer for SUEZ in North America. He has more than 20 years' experience in leading business transformation and innovation in large-scale and global companies.

"Digital and disruptive technologies are revolutionising the world at an incredible pace and in a defence industry environment this is especially challenging," BAE Systems Australia CEO Ben Hudson said.

Source: Defence Connect

New LM MISSILE ROLE

LOCKHEED MARTIN (LM) has appointed Ken Kota as vice president, Australian Defence Strategic Capabilities Office. Kota will lead LM's approach to delivering a sovereign guided weapons capability as part of the Australian Guided Weapons and Explosive Ordnance Enterprise.

In the newly created role, he will aim to leverage LM's expertise in missile design and manufacture to accelerate the development of advanced guided weapon manufacturing capabilities in Australia.

According to LM, that includes "ensuring expedient access to existing technologies and systems currently utilised in Lockheed Martin's advanced weapons factories, rapidly mobilising a highly skilled workforce and establishing the local industry partnerships needed to manufacture and maintain critical guided weapons".

Source: Australian Defence Magazine

THE RED ARROWS

The Red Arrows training over Greece.
Photo: © MOD Crown Copyright 2022.

ESTABLISHED AFTER WWI TO SECURE THE FUTURE OF THE RAF, THE RED ARROWS IS NOW ONE OF THE WORLD'S FINEST AEROBATIC DISPLAY TEAMS.

FOLLOWING THE GRIM YEARS OF WORLD WAR I, the future of the Royal Air Force (RAF) looked bleak. Britain's population was war weary and faced severe austerity measures. The army and navy were greatly scaled down and there were calls to disband the RAF as it was felt that an independent air force was no longer required. It was the same crisis of existence the Royal Australian Air Force suffered in the 1920s and 30s.

Faced with significant budget cuts, the Chief of Air Force, Sir Hugh Trenchard, realised he needed tax payer support to assist with securing the RAF's existence. In 1920, he decided to showcase the RAF in a public air pageant at Hendon aerodrome. It was such a success that it became a regular event, attended by members of the Royal family and other dignitaries with special spectator boxes for members of the Houses of Parliament. It drew crowds of up to 195,000 spectators.

The pageants featured displays of air power with the enactment of bombing and strafing of ground targets, shooting down barrage balloons and aerobatic team displays. The utility of air power was clearly demonstrated to the public, swaying opinion and assuring the continued existence of the RAF through the turbulent years of the early 1920s.

Air pageants retained their popularity and success through to the 1930s when public interest began to wane and international sensitivities appeared with the looming threat of World War II.

LEFT The Black Arrows.

BELOW A Folland Gnat.

BOTTOM A formation flypast with the RAF Voyager tanker at the Royal International Air Tattoo. Photo: Cpl Will Drummee RAF/ © MOD Crown Copyright 2022.

EARLY TEAMS

The post WWII RAF was keen to take advantage of the goodwill it had built during the war. Air shows commemorating the Battle of Britain were held at active flying stations and the funds raised were donated to the RAF Benevolent Fund.

The first aerobatic display team to use jet aircraft came from an on-line squadron flying de Havilland Vampires to be replaced by Gloster Meteors and then by Hawker Hunter aircraft in 1955. The Hunters were painted black and during an air show in France were dubbed the Black Arrows. The Black Arrows were noted for barrel-rolling a formation of 19 aircraft. A remarkable feat.

Through the 1950s and 60s there were several aerobatic display teams operating in the RAF and Air Force commanders felt too much time was being spent practising formation flying rather than focusing on operational training. In 1964, all RAF teams were amalgamated into the Royal Air Force Aerobatic Team flying Folland Gnat aircraft with a red colour scheme. The colour was a follow on from a previous team, the Red Pelicans flying BAC Jet Provosts painted red for safety in their training role and to provide better visibility for displays. The Red Arrows took their name from a blend of the Red Pelicans and the Black Arrows.

THE RED ARROWS

The first team of seven members, led by Squadron Leader Lee Jones, completed its debut display on 6 May 1965. By the end of their first season, the Red Arrows had displayed 65 times in Britain, France, Italy, Holland, Germany and Belgium and were awarded the Britannia Trophy by the Royal Aero Club for their contribution to aviation. Squadron Leader Jones later transferred to the RAAF and served as a flying instructor on Vampire aircraft at No.1 Applied Flying School, RAAF Pearce, WA, in the late 1960s and early 70s.

With the change of leadership in 1968, the team was expanded from seven to nine and flew a 'diamond nine' formation which remains their trade mark some 50 years later. In 1969, the Red Arrows were permanently established as a standard RAF squadron. After nearly 1,300 displays in the Gnat, the team was equipped with BAE Hawk aircraft in 1979.

The Hawk is a low-wing transonic two-seat training aircraft used in several roles in the RAF and is expected to remain in service with the Red Arrows until 2030.

Previously used in advanced flying training, current primary employment of the Hawk is in the 'aggressor role' simulating enemy aircraft and employing adversary tactics. Other roles include close air support training for land units and a war role when equipped with two Aim-9L Sidewinder heat-seeking air-to-air missiles. It has a top speed of 550kts (1,028kph) and a range of 1,360 nautical miles (2,520km). The Hawk is due to be withdrawn from its operational and training roles this year.

All members of the Red Arrows are volunteers who have completed one or more operational tours on fast jets, have

WORLD-CLASS SUPPLIER

AIRCRAFT PARTS, SPARES AND SERVICE

MHD-ROCKLAND has over 40 years of experience in providing reliable aircraft parts, services and support to Defence Customers world-wide. Our team delivers superior assistance and fast access to locally held inventory. We are focussed on minimizing downtime and keeping you mission ready.

- Locally Held Inventorytory
- Reduced Lead Times
- Major OEM Partners
- Local Support & Service

MHD ROCKLAND est. 1981

AUSTRALIAN TRUSTED TRADER

PPG

MHD-R is the distributor of PPG's Military Aircraft Transparency Products in Australia and New Zealand.

+ 61 7 3279 1704 | australia-info@mhdrockland.com

MHDROCKLAND.COM

Trademark diamond 9 formation. Photo: Cpl Ashley Keates/© MOD Crown Copyright 2019.

accumulated more than 1,500 flying hours, and have been assessed as above average in their operational roles. Their previous employment typically includes operational tours in Afghanistan and Libya, or part of the Quick Reaction Alert in the UK and the Falkland Islands. Team members serve with the Red Arrows for three years, with three team members changing over each year. Team leaders complete a three-year tour before consideration for appointment as Red 1. The current team leader flew in the Red Arrows for the 2015-17 seasons. He was Red 5 in his first year before becoming a member of the synchro pair for the remainder of this first tour.

Overall command of the team is exercised by the Officer Commanding, a Wing Commander, who has previous experience within the team. The current Officer Commanding is a former Red 1 who led the Red Arrows in 2016 on two global tours across Europe, the Middle East and into China for a series of displays and diplomatic engagement.

THE DISPLAYS

Team members flying the Red 1 to Red 5 positions perform close formation aerobatics while Red 6 to Red 9 perform more dynamic manoeuvres with Red 6 and 7 flying synchronised displays. Red 6 is the leader of the pair. As there are no reserve pilots on the team, if a pilot is not available to fly then the size of the formation is reduced for the display. If the leader, Red 1, is unable to fly, the team does not perform. Red 10, a Squadron Leader, is the safety supervisor and the voice of the Red Arrows at air shows. During a display, he acts as the team's supervisor and maintains two-way radio contact with the Team Leader.

The formation avoids flying directly over spectators apart from the initial entry to the presentation which is typically from behind the crowd. Manoeuvres in front of and parallel to the audience can be as low as 300ft (91m), the synchro pair can fly as low as 100ft (30m) straight and level, or 150ft (46m) in inverted flight. To carry out a full looping display, the cloud base must be above 5,500ft (1,700m) to avoid the team entering cloud while looping. If the cloud base is less than 5,500ft but more than 2,500ft (760m) the team will perform a 'rolling display', substituting wing-overs and rolls for vertical manoeuvres such as a loop. If the cloud base is less than 2,500ft, the team will fly the 'flat display', which consists of a series of fly-pasts and steep turns.

Low-level display flying is demanding and, while providing an exciting demonstration of flying skill, it is not without risk. The Red Arrows have lost nine Gnat and 12 Hawk aircraft in accidents since 1969 while 12 pilots have lost their lives during either air displays or practice sorties. There have been four mid-air collisions and several incidents of aircraft hitting the ground. In the most recent accident, in 2018, a technician in the rear seat was killed when the Hawk hit the ground. Several pilots have also suffered serious injuries, but despite the losses, the team continue to attract volunteers.

While performing precision flying displays, the Red Arrows also provide other functions. They represent the RAF and demonstrate the skills and dedication of military pilots. Being renowned for excellence, the Red Arrows showcase and reinforce the reputation of the UK, its industry and national educational initiatives to encourage public interest in science, technology, engineering and mathematics subjects. They are also a positive motivator for RAF recruitment drives.

In 1977, the British Ministry of Defence introduced display charges. From an initial charge of £200 (A$380) for a Red Arrows display, the charge had risen to £2,000 (A$3,800) in 2000 and by 2019 it had increased to £14,000 (A$27,000).

SUPPORT TEAM

The pilots performing aerobatic displays all over the world are just part of a much larger team. The support team comprises 130 people, called the Blues because of their blue display overalls. They are drawn from the wider RAF and the RAF Reserve. Engineering Support Flight is responsible for maintaining quality assurance and engineering records, while 20 technicians support the aircraft primary systems. The support team is also responsible for logistics, safety equipment, ejection-seat and g-suit maintenance, photography and a dye team to supply the coloured smoke. An RAF Atlas A400M transport aircraft supports the Red Arrows when deployed for overseas air shows.

TRAINING

The Red Arrows begin training for the forthcoming season almost as soon as the previous season has ended. Typically, winter training starts in October, with small groups of three or four aircraft formations. Each pilot flies three sorties a day, five days a week, and the formations grow in aircraft number as training progresses.

Each flight involves a thorough brief, debrief and discussion to ensure safety is paramount and the formations are precise. One complete training cycle comprising these elements lasts about two hours, usually with a 30-minute flight.

Winter training lasts until mid-March, when the team usually moves overseas to a location with more predictable, settled weather to maximise flying opportunities to perfect the display. During the training period, the team is assessed by senior RAF officers, with the aim of gaining Public Display Authority. If awarded, the team's pilots change from green coveralls into their famous red flying suits and the ground crew adopt their royal blue display overalls. The season then officially begins and public performances by the Red Arrows are authorised.

AIR SHOWS

In 2019, the Red Arrows embarked on a major overseas deployment to Canada and the United States. During its largest visit to the North American continent in more than a decade, the team performed more than 20 displays at various locations. Designed

ABOVE The Blue Team.

LEFT Red 6 to Red 9 - horizontal bomb burst.

BELOW LEFT Atlas A400M support transport.

BOTTOM LEFT Precision flying with low cloud cover. Photo: Sean Alabaster.

BOTTOM RIGHT Basic echelon right formation. Photo: © MOD Crown Copyright 2022.

as a training aircraft, the Hawk does not have the range to make the North Atlantic crossing and is not equipped for air-to-air refuelling. So, after leaving their home base at RAF Scampton, Lincolnshire, the Red Arrows made stops in Scotland, Iceland and Greenland before reaching Canada and then Halifax for their first display.

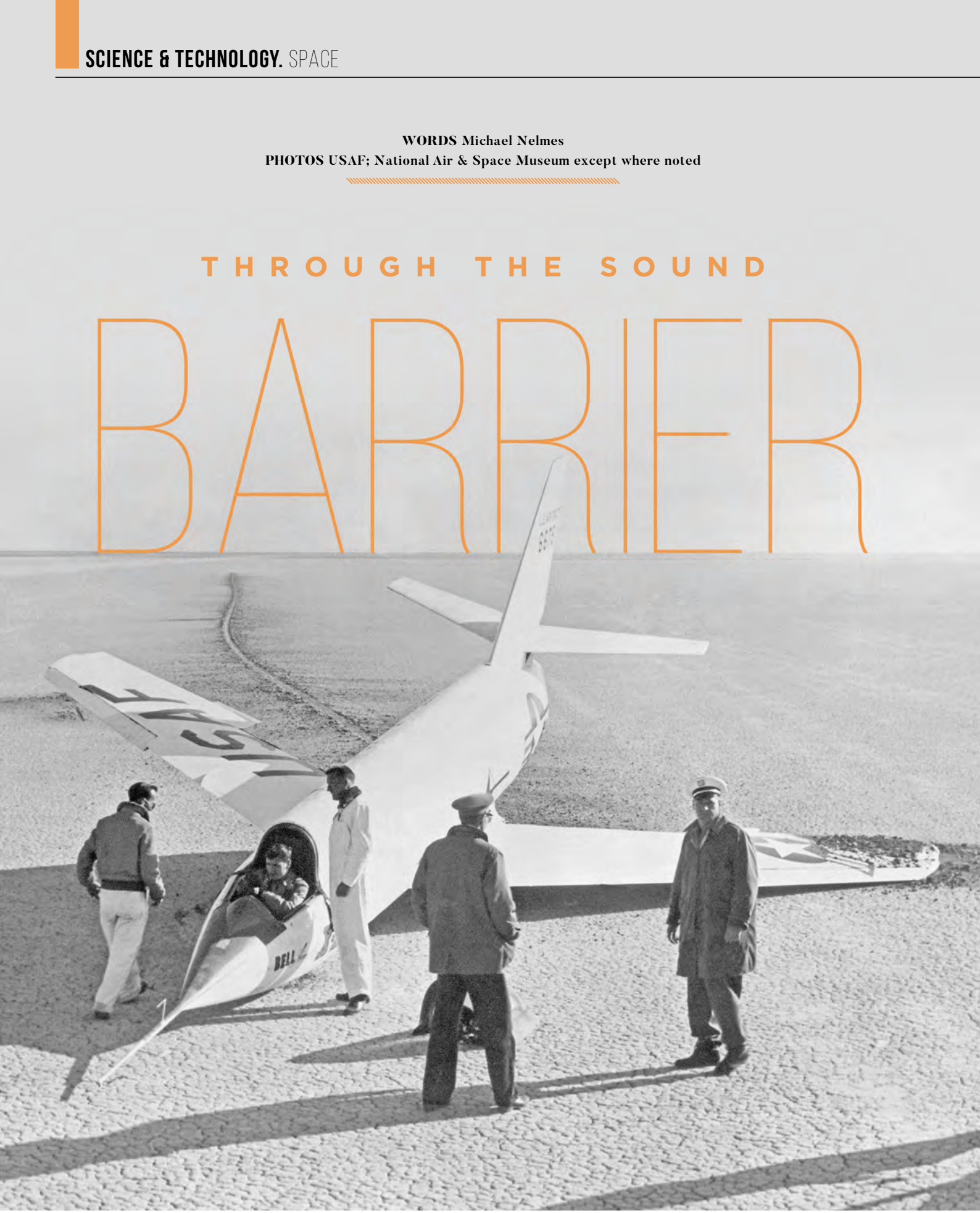
In 2021, the team participated in 37 public displays and 22 major flypasts in the UK and at air shows in Estonia, Poland, Belgium and Malta, as well as a visit to the United Arab Emirates.

This year they are performing more than 65 times in England, Scotland, Wales and Northern Ireland – the busiest domestic season for four years. The aerobatic show features a combination of crowd favourites and innovative shapes, including a formation to honour the Platinum Jubilee of Her Majesty Queen Elizabeth II.

Now in their 58th season, the Red Arrows have performed at more than 4,500 air shows in 54 countries. They are one of the finest aerobatic display teams in the world.

WORDS Michael Nelmes
PHOTOS USAF; National Air & Space Museum except where noted

THROUGH THE SOUND BARRIER



AS AUSTRALIA ESTABLISHES ITS PLACE IN SPACE, WE LOOK BACK TO THE FORMATIVE YEARS OF AMERICA'S QUEST FOR HIGH-SPEED AND HIGH-ALTITUDE FLIGHT – A QUEST THAT BEGAN ITS JOURNEY INTO SPACE.

THE 'MERCURY SEVEN' ASTRONAUTS chosen in 1959 to pilot the manned spaceflights of the Mercury program were all military test pilots. NASA believed that breed of individual had the 'right stuff' to handle the challenges space flight would throw at them. In order to provide fertile ground for recruitment by NASA, and also foreseeing its own role in space, the US Air Force (USAF) included six months of space-related studies in its test-pilot training curriculum: advanced mathematics, orbital mechanics, bioastronautics, aero-thermodynamics, spacecraft design, and zero-gravity flights in a KC-135 tanker (the 'vomit comet') to familiarise pilots with the conditions of space flight.

The links between upper atmospheric supersonic flight and space flight were forged at the dawn of the space age. But to complete the picture we have to go back to the 1930s and 40s, to the origins of supersonic flight.

PUSHING THE ENVELOPE

The projects of Lockheed's 'Skunk Works' advanced development projects department represent a sample of the technological developments in American aviation since World War II. Lockheed's P-38 Lightning fighter was one of the first aircraft capable of diving fast enough to encounter 'compressibility' – the potentially catastrophic effect on aircraft control and structural integrity at speeds approaching that of sound (Mach 1). Lockheed's aeronautical engineers were aware of this phenomenon when they began design work on the P-38 in 1937.

While Skunk Works is undoubtedly the best-known US aerospace development office in high-speed, high-altitude aircraft design, pioneering work was also done by other aerospace companies such as Bell, Douglas, Northrop, Convair and North American. Their projects resulted in a series of US experimental aircraft and rockets known as X-planes (not to be confused with the X-prefixed prototypes of production aircraft, e.g. XP-38). So far, they have numbered from X-1 to X-62. By and large they have not been intended for series production but were built as one-offs or in small numbers to investigate certain phenomena, technologies and capabilities. There have been exceptions, such as the X-35 which became the F-35.

Many X-plane projects are carried out in secret. Hence, their flight test programs are conducted away from prying eyes and ears – at the remote Edwards Air Force Base (AFB), California (named Muroc prior to 1948), White Sands Missile Range, New Mexico, or NASA facilities. Some did not get that far and were never built. But the projects that did eventuate tell a fascinating story of overcoming unique technical, physiological and even psychological challenges. We'll start with the first X-plane: the X-1, or XS-1 (S for supersonic) as it was originally known.

BELL'S ROCKET PLANE

The first challenge was to break through what came to be known as the sound barrier. There is in fact no such barrier. But some aerodynamicists predicted that as Mach 1 was approached, the compressed air, or shock wave, in front of an aircraft would produce too much drag to be overcome – that it would effectively produce an impenetrable air wall. Others pointed out that bullets and even the tips of whips had for many years been exceeding Mach 1.

In 1939, an engineer at Wright Field (now Wright-Patterson AFB), Dayton, Ohio, named Ezra Kotcher suggested that the Army Air Corps should sponsor the development of an aircraft to investigate transonic flight. It was not until 1943 that the idea was given serious consideration,

ABOVE USAF CAPT Chuck Yeager in the Bell X-1. *Glamorous Glennis* was named after his wife, as was his wartime P-51 Mustang fighter.

LEFT Bell X-2 at Edwards AFB after its first glide flight, April 1952

as the P-38 and Republic P-47 Thunderbolt, in particular, were by then experiencing the problem of compressibility during high-speed dives in combat. Soon a growing number of fighter designs, of both US and overseas origin, could reach at least Mach 0.7 in a dive, but limitations such as propeller propulsion, thick wings with traditional airfoil profiles, and fully-manual flight control surfaces made them unsuited for transonic flight. Skunk Works' 'Kelly' Johnson saw those limitations in the P-38 he co-designed, leading to measures including 'compressibility control' flaps on the wing under surface, and hydraulic power-boosted ailerons.

The Bell Aircraft Corporation at Buffalo, New York, produced America's first production jet aircraft, the P-59 Airacomet fighter, which was first flown at Muroc in October 1942. Although slower than the fastest piston-engine fighters, the P-59's development made Bell a prime choice to build the first aircraft capable of exceeding Mach 1. But given the relative lack of power and reliability of early jet engines, that feat would require a rocket motor.

In December 1944, Bell engineers Robert Woods and Robert Stanley assembled a team to design the XS-1. In some respects, they had to work with their best guesses based on estimates of how an aircraft would behave at Mach 1. The wind tunnels of the era could provide no useful data on aerodynamic issues at speeds over Mach 0.75, because the shock waves produced by test models were reflected off the tunnel walls and back at the model. Slotted tunnel walls were later developed to solve that problem. Woods and Stanley designed the XS-1's fuselage to be shaped much like a 0.50-inch calibre bullet as it provided readily available data without the need for supersonic wind tunnel analysis.

A contract was signed in March 1945 between Bell, the USAF and the National Advisory Committee for Aeronautics (NACA, succeeded in 1958 by National Aeronautics and Space Administration, NASA) and the first XS-1 was rolled out of assembly in December, painted bright orange for visibility. Its mission was to "safely explore the transonic speed envelope", i.e. speeds approaching and exceeding that of sound, or 1,235kph at sea level at 20°C (the speed of sound is directly proportional to temperature; as temperature increases, the speed of sound

ABOVE The X-1 was shaped like a bullet.

increases). Given the unknown forces that the airframe might have to endure, it was over-engineered to withstand a remarkable 18g positive and negative acceleration. Power was provided by a four-chamber rocket motor fuelled by ethyl alcohol oxidised with liquid oxygen. Enough fuel was carried for just five minutes of powered flight.

On the other side of the Atlantic Ocean, on 27 September 1946 came sobering news of the death of British test pilot Geoffrey de Havilland Jr. His de Havilland DH.108, an aircraft with swept-back wings resembling Germany's wartime 1,000kph Messerschmitt Me 163 rocket-powered interceptor, had disintegrated at Mach 0.9.

If a swept-wing aircraft could disintegrate, then how would the X-1 with its straight wings fare in the transonic realm? There was only one way to find out. On 14 October 1947 the craft, carrying Chuck Yeager with broken ribs after a fall from a horse, was air-dropped by a B-29 mother ship flying at 20,000 feet over the Mojave Desert. It was its ninth powered flight. In his autobiography, Yeager described how he entered the history books: *I fired all four rocket chambers in rapid sequence. We climbed at .88 Mach and began to buffet, so I switched the stabiliser switch and changed the setting two degrees. We smoothed right out and at 36,000 feet I turned off two rocket chambers. At 40,000 feet, we were still climbing at .92 Mach. Levelling off at 42,000 feet, I had 30 percent of my fuel, so I turned on rocket chamber three and immediately reached .96 Mach. I noticed that the faster I got, the smoother the ride.*

Suddenly the Mach needle began to fluctuate. It went up to .965 Mach – then tipped right off the scale. I thought I was seeing things! We were flying supersonic!

BELL XS-1 ORIGINAL SPECIFICATIONS

CREW: 1

LENGTH: 9.42m

WINGSPAN: 8.53m

GROSS WEIGHT: 5,556kg

EMPTY WEIGHT: 3,175kg

MAX ALTITUDE: 70,000ft+

POWERPLANT: Reaction Motors XLR11-RM3 rocket engine of 2,720kg thrust at sea level

POWERED ENDURANCE: 2.5 to 5 minutes

MAX SPEED: Mach 1.45 (1,545kph)

ABOVE The X-1's four rocket chamber nozzles.

ABOVE Cockpit of the X-1.

Looking for the next step in your Career?

USE YOUR QUALIFICATIONS, TRAINING AND EXPERIENCE TO BECOME A CIVILIAN AVIATION LICENSED AIRCRAFT MAINTENANCE ENGINEER.

Realise your potential and join the host of engineers who have successfully gained a CASR, DASR or EASA Part 66 Licence outcome with Aviation Australia.

Aviation AUSTRALIA

EXCELLENCE IN AVIATION TRAINING

RTO No. 30770 | CASA.147 MTO 0025

SCAN TO FIND OUT MORE

07 3860 0900
industry@aviationaustralia.aero
www.aviationaustralia.aero/industry

Down below in the NACA tracking van, the first sonic boom from an aircraft, like the rumble of distant thunder, was recorded. The X-1 had reached Mach 1.07, or 1,126kph.

It was not, in fact, the world's fastest flight. That honour rested with German test pilot Heini Dittmar who had achieved a flight speed of 1,130kph in a Me 163, recorded in July 1944. Dittmar's achievement was not official, as the aircraft was operating in secrecy (although it had already seen some limited combat trials against American heavy bombers over Germany). But as Dittmar's flight was at lower altitude (warmer temperature), where sound travels faster, it is generally agreed that he was not supersonic, despite a claim that a sonic boom was heard.

Three weeks after Yeager exceeded the speed of sound, he broke Dittmar's speed with a flight at Mach 1.35 (1,456kph). Of 18 pilots to fly the X-1, Yeager made the most flights with 34.

IMPROVING THE DESIGN

One thing that became clear during flight tests was that the X-1's elevators became less effective at high speed. The solution was to allow the pilot to change the incidence angle of the tailplane – an early version of the all-moving tailplane, or stabilator, common today.

After three X-1s had been built and flown, Bell produced three second generation X-1s: the X-1A, B and D. On 12 December 1953 Yeager took the X-1A to Mach 2.44 (2,655kph) at 75,000ft. Although encountering a potentially catastrophic phenomenon known as inertia coupling (the aircraft rolls about its forward inertial vector rather than it's physical longitudinal axis and departs controlled flight), he was able to regain control of the aircraft and return to base unscathed.

The second of the original X-1s was modified in 1955 to produce the X-1E. It differed from the first six aircraft with wings just half the thickness of the already thin originals and featured a turbine fuel pump. The X-1E reached Mach 2.24 in 1957.

Greater changes came with the X-2 of 1952, which was larger and featured swept-back wings and tailplane – an idea inspired by German research going back to 1935 and revived by NACA engineer Robert Jones. Design work began as early as October 1945, before the first X-1 was rolled out. Its construction used steel alloys, which could withstand higher

frictional temperatures than aluminium, and its Curtiss-Wright rocket motor could produce 6,800kg thrust, more than twice that of the X-1. It first flew in 1952, some years after the swept-wing North American F-86 Sabre entered service and, like its predecessors, the X-2 was air-launched from a bomber.

In 1956, a second X-2 unofficially set new altitude and speed records: 125,907ft and Mach 3.196 (3,370kph). Unfortunately, another inertia coupling incident was that time disastrous, cost the pilot's life and destroyed the aircraft.

The Bell family of X-planes saw humans first travel faster than sound, and as such their flights are important milestones in aerospace history.

For a three-minute video of X-1 footage and an interview with Chuck Yeager, scan the QR code.

ABOVE The first Bell X-1 is today displayed at the Smithsonian's National Air & Space Museum, Washington DC. Behind it is America's first jet, the Bell P-59 Airacomet. Photo: author.

LEFT Test pilot Joe Walker with the X-1E.

BELOW X-2 launch from B-50 mothership

ABOVE X-2 with twin set of shock-diamonds characteristic of supersonic conditions in the exhaust plume from the two-chamber rocket engine. Photo: NASA.

MilCIS 2022

MILITARY COMMUNICATIONS AND INFORMATION SYSTEMS
CONFERENCE AND EXPO

JOIN US IN PERSON OR VIRTUALLY AT THE CONFERENCE AND EXPO

REGISTER TODAY

15–17 November 2022
National Convention Centre Canberra Australia

www.milcis.com.au

MilCIS Conference Delegates pay the relevant conference registration fee and have full access to all conference presentations (five parallel streams including the Expo presentations in the Royal Theatre), daily breakfast and lunch product sessions, the MilCIS Exhibition Hall, daily conference morning/afternoon teas and lunches, and the conference dinner.

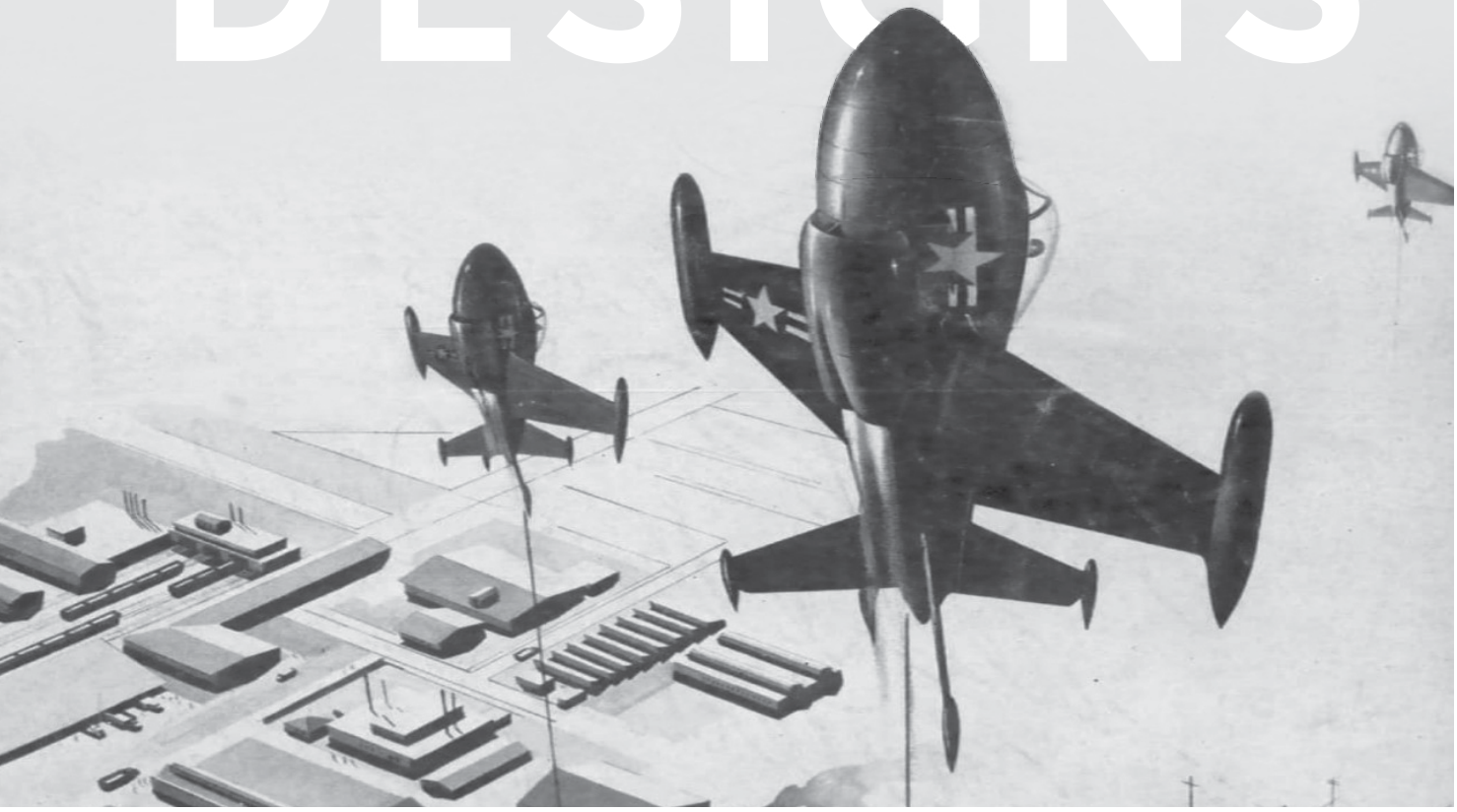
MilCIS Expo Visitors must register to attend but have complimentary access to the MilCIS Exhibition Hall and to the MilCIS Expo presentations that run throughout the conference in the Royal Theatre. MilCIS Expo Visitors DO NOT have access to the presentations in the conference parallel sessions, daily catering, nor the conference dinner.

GR4 TORNADO

WINGS VOLUME 74 NO.3

A Royal Air Force GR4 Tornado after refuelling from a RAAF KC-30A tanker on an Operation Okra mission in Iraq.

RADICAL DESIGNS



TOP Artists depiction of FV-1s taking off.

ABOVE XFV-1 number one on its first flight, with ungainly but adequate temporary landing gear for conventional takeoffs and landings. Photo: US Navy.

IN THIS EXCERPT OF OUR SKUNK WORKS SERIES WE LOOK AT THREE PROJECTS DESIGNED AT ROUGHLY THREE DECADE INTERVALS TO SATISFY VERY DIFFERENT REQUIREMENTS.

SKUNK WORKS WAS BORN IN 1943 with the secret XP-80 jet fighter project. Its embryonic team of Kelly Johnson and Hall Hibbard formed even earlier, working together on the P-38 fighter design from 1937. Between the P-38 Lightning and the present-day F-35 Lightning II, the projects of Skunk Works have been many and varied. Three such projects, designed at roughly three decade intervals, were intended to meet very different requirements.

The first of the radical designs was one of a rare and short-lived breed of vertical take-off and landing craft of the 1950s – vertical in the truest sense, as the aircraft stood on its tail.The second, the YF-22 fighter prototype designed in the 1980s, was originally named Lightning II well before that name went to the F-35. Production F-22s were subsequently named Raptor. The F-22 is now the oldest fifth-generation stealth fighter, and arguably still the most capable.The third aircraft is the enigmatic, yet-to-be-realised SR-72 – intended to reach twice the speed of the world's fastest aircraft, the SR-71 Blackbird, which was retired in 1999.

VERTICAL RISER: THE XFV-1

In July 1950, the US Navy secretly requested bids, under its OS-122 program, for the creation of a Vertical Take-Off and Landing (VTOL) shipboard fighter aircraft for convoy protection. Bids from five airframe contractors – Goodyear, Martin, Northrop, Convair and Lockheed – were received. At the time, VTOL didn't just mean that it rose into the air vertically; the aircraft itself sat vertically on its tail, its nose in the air.

Convair and Lockheed were approved to proceed, and Lockheed's proposal was pursued in secret within the Skunk Works under project engineer Art Flock Jr. In April 1951, the Navy ordered two examples of the experimental Lockheed Model 081-40-01, designated XFO-1 (later XFV-1), although only the first example was actually flown. Lockheed promoted it as the Vertical Riser or Rising Star.

The Allison XT40-A-6 turboprop was a stand-in engine for the more powerful version intended for dedicated VTOL flight tests, the 7,100 shaft horsepower YT40-A-14.

For emergencies, the XFV-1 was to be equipped with a 'parachute means of landing aircraft' system invented by Gene Frost. It was a large-diameter parachute on a stationary shaft within the propeller spinner. In an emergency during vertical takeoff or landing, the parachute could be deployed to safely lower the aircraft down for a four-point landing on its tail wheels.

The aircraft made its first official flight on 16 June 1954, fitted with temporary landing gear to take-off in conventional horizontal attitude. In fact, the aircraft never did take off or land vertically, as its interim engine provided insufficient power. It did, however, transition from horizontal to vertical flight and back, and briefly hovered, during its test program. A follow-on production XFV-2 version was planned but not proceeded with. The XFV-2 was to use the more powerful Allison T54-A-16 turboprop engine, which never materialised. It would also have featured armour plating around the cockpit, a bulletproof windscreen, and a radar dish inside the non-rotating part of the propeller spinner. Armament was to comprise four 20mm cannon, housed in wingtip pods interchangeable with pods carrying 24 unguided 2.75-inch diameter 'Mighty Mouse' folding-fin aerial rockets.

In 1956, the US Navy cancelled its convoy fighter program after the XFV-1 had made 32 flights with conventional take-off and landings. Lockheed received no further funding for the project, and nor did Convair for its 'Pogo' (see page 42). Neither design had enough propulsive power to exceed 600mph (965kph) as had been hoped; and moreover, the piloting skills needed to operate such an

XFV-1 SPECIFICATIONS

CREW: One (pilot)

PROPULSIVE SYSTEM: One axial-flow Allison XT40-A-6 turboprop engine of 5,850 shaft-horsepower driving two three-bladed contrarotating propellers.

LENGTH: 11.02m

WINGSPAN: 9.30m

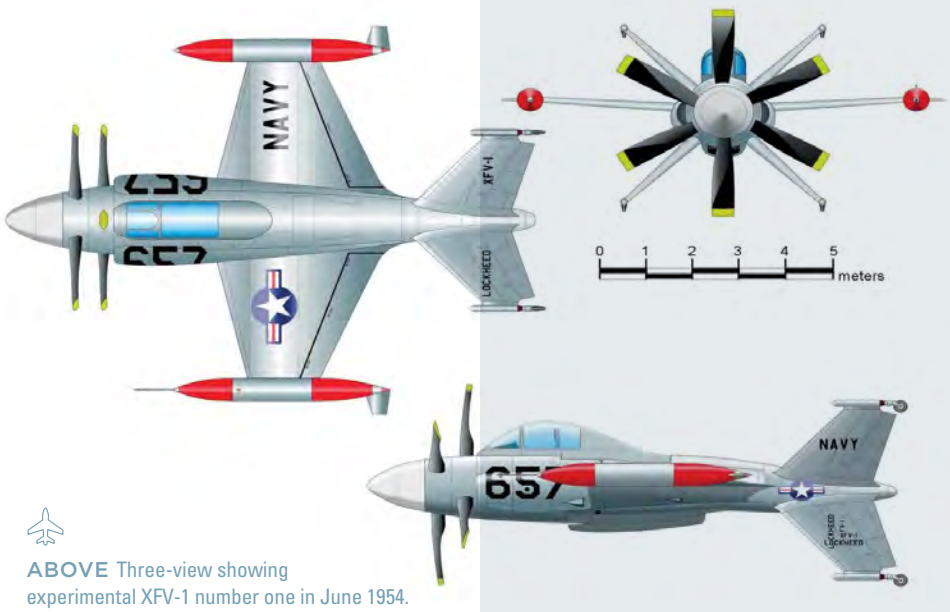
GROSS TAKEOFF WEIGHT: 7,239kg

MAXIMUM SPEED: 845kph at 35,000ft

MAXIMUM RANGE: 45 minutes endurance

SERVICE CEILING: 47,000ft

ARMAMENT: Production examples were to have four 20mm cannon (150 rounds each) or 48 2.75-inch folding-fin aerial rockets



ABOVE Three-view showing experimental XFV-1 number one in June 1954. Artwork: Giuseppe De Chiara.

ABOVE Chief engineering test pilot Herm Salmon boarding XFV-1 number one a few months before its first flight, 16 June 1954. Photo: US Navy.

aircraft were far too demanding. Neither ascended from terra firma again.

Lockheed later gave the XFV-1 the name 'Salmon' in honour of the only person to fly it, company engineering test pilot Herman 'Fish' Salmon and, like a spawning salmon, the aircraft had to go directly 'upstream' before it could fly in normal fashion.

The first XFV-1 now resides at Lakeland Airport in Florida. The second XFV-1, intended for static structural tests and never completed, is on display at Los Alamitos Army Airfield, California.

LEFT XFV-1 in launch position. Photo: LM Code One.

Scan the QR code, left, to see a five-minute film film of early XFV-1 and XFY-1 flights.

For a four-minute interview with XFY-1 test pilot Skeets Coleman and footage of the X-13, scan the QR code, left.

'VERTIBIRDS' OF A FEATHER: POGO AND VERTIJET

One basic requirement for a vertical take-off aircraft is that its thrust exceeds its weight. In addition to the Salmon, two other US aircraft of the 1950s were so endowed.

The XFY-1, Pogo, was the Convair company's proposed answer to the Navy's OS-122 program. It was similar in layout to the Lockheed XFV-1 and had the same engine, but featured a delta wing configuration. It first rose from the ground, tethered by cables, in April 1954 and a free untethered flight was made the following August, two months after the Lockheed XFY-1's first flight. The single example produced is now at the National Air and Space Museum (NASM), Washington, DC.

The more advanced Ryan X-13 Vertijet arose from a 1947 US Navy contract for a study into the feasibility of submarine-launched jets. However, naval interest in that idea declined and in 1953 the USAF instead contracted Ryan to build a prototype VTOL jet, designated X-13. It featured a high-mounted delta wing and a high-powered version of the Rolls Royce Avon engine. Thrust vectoring (directional control of engine thrust) for pitch and yaw control was augmented by small reaction jets on the wingtips for roll control.

The first completed X-13 flights, from vertical take-off through transition to horizontal flight to descent, were made from a vertical launch rig at Edwards Air Force Base, California in 1957. Flights at over 650kph and up to 20,000 feet were made. One of the two examples built was transported across the country, and a landing was made at the Pentagon in Washington, DC. *Life* magazine reported that "combat versions could dispense with the platform and land on a cable stretched between two trees". However, due to a lack of operational requirement, the X-13 concept did not progress past prototype stage. The pair are now museum pieces – one owned by NASM, the other by the National Museum of the US Air Force at Dayton, Ohio.

ABOVE RIGHT Convair XFY-1 Pogo c1954.

RIGHT Ryan X-13 Vertijet hovers at its launch rig at Edwards Air Force Base in 1957. Photo: USAF.

ADVANCED TACTICAL FIGHTER: THE YF-22 RAPTOR

Two flights each of eight F-22 Raptors, flying from an undisclosed base in Germany, rendezvous with a flight of six B-2 Spirit stealth bombers over eastern Europe. Approaching the north-western border of Ukraine, they carry a full complement of 20mm cannon ammunition, and are armed with infrared- and radar-guided air-to-air missiles.

That is just one of several projected scenarios as war and civil unrest continued in Ukraine, Iraq and Syria and tensions mounted between Russia, ISIS, and the United States.

The US Air Force's F-22 Raptor is an air dominance stealth fighter. It can gain and maintain control of the air arena by outperforming its adversaries with advantages in speed, firepower, range, avionics, maneuverability and stealth. While the F-22 fleet is relatively small compared to other USAF fighter fleets, it can deliver a wide variety of air-to-air and air-to-surface ordnance.

Crucially, with its very low observable technology, the F-22 can remain undetected. Anti-radar measures include coating in radar-absorbent material, its air inlet geometry, hidden engine turbines and aligned airframe edges. Measures against heat-seeking missiles include flat thrust-vectoring jet nozzles which reduce infrared emission from its exhaust plumes, and active cooling of its leading edges to reduce heat buildup during supersonic flight.

F-22A Raptor makes a high speed pass with engines in afterburn. Noteworthy are the closely-coupled stabilator and wings. Photo: LMSW.

The F-22 emerged from the USAF's Advanced Tactical Fighter (ATF) program begun in 1981 to supplement and then replace the F-15 Eagle. From seven contenders, Headquarters USAF, in 1986, selected Lockheed and Northrop as primary airframe contractors to produce the ATF. Those firms teamed with principal contractors Boeing and General Dynamics (Lockheed) and McDonnell Douglas (Northrop). Each team was contracted to produce two service test aircraft, respectively designated YF-22 (unofficially, Lightning II) and YF-23 (Black Widow II and Gray Ghost).

YF-22 PROTOTYPE AIR VEHICLES

Since two power-plant contractors – Pratt & Whitney and General Electric – were contending to produce the propulsive system for the winning ATF design, each firm was contracted to produce service test examples of their axial-flow turbofan engines, respectively designated YF119 and YF120. One YF-22 and one YF-23 Prototype Air Vehicle (PAV) would be powered by two YF119s, while the other two aircraft would use two YF120s.

Thus, the USAF would have four choices, and the winner would be the preferred airframe and power-plant combination.

The first Lockheed-Boeing-General Dynamics YF-22 (PAV-1) was powered by General Electric YF120 engines. Test pilot David Ferguson first took it into the air from Palmdale on 29 September 1990, landing uneventfully at Edwards Air Force Base (AFB) after an 18-minute flight. The Pratt & Whitney YF119-powered YF-22 (PAV-2), externally the same as PAV-1, was flown a month later and emerged as the preferred combination out of the two YF-22 and two YF-23 contenders. Secretary of the Air Force, Dr Donald Rice, announcing the winner on 23 April 1991, described the combination as having "clearly better capability with lower cost, thereby providing the Air Force with a true best value".

Lockheed was awarded an engineering, manufacturing and development (EMD) contract to produce seven single-seat F-22As and a pair of tandem-seat F-22B pilot training and transition airplanes. The F-22Bs were later canceled and replaced by an additional two F-22As, for a total of nine EMD airplanes.

Pratt & Whitney Aircraft Engines was given the green light to produce the F119 EMD engines, plus spares. The F119 engine has a length of 5.16m, diameter of 1.17m and weighs 1,770kg. It is a twin-spool, counter-rotating, low-aspect-ratio engine with a three-stage low pressure/six-stage high pressure compressor and an annular combustor. With a thrust-to-weight ratio of 7.95 to 1 (by comparison, the ratio for the SR-71 Blackbird's J58 engine was 5.2 to 1) the F-22's two F119s can propel it to Mach 2.25.

Some felt that the Northrop-McDonnell Douglas YF-23 should have won the ATF competition. It was even stealthier than the YF-22 and could fly higher and further, although the YF-22 with thrust vectoring was more agile. Its twin wide-spaced, outward-canted tail planes (dubbed ruddervators) served as horizontal stabilisers, vertical stabilisers, elevators and rudders. The YF120-powered YF-23, first of the two to fly, reached Mach 1.6 (1,960kph) in supercruise on its second flight.

From EMD contract to completion of the first EMD F-22A took six years. Dubbed *Spirit of America*, it was ceremoniously rolled out on 9 April 1997.

ABOVE YF-22 (PAV-1) in three-view as it appeared on its 29 September 29 1990 first flight. Artwork: Giuseppe De Chiara.

Five months later, Raptor 01, as it was now known, made its first flight on 27 September 1997 with F-22 chief test pilot and USAF veteran, Alfred P. (Paul) Metz, at its controls. Metz also made the first flight of the premier YF-23 as Northrop's ATF chief test pilot, thereby becoming the only pilot to fly both ATF types.

In the meantime, in 1993 the Lockheed Aircraft Corporation had purchased the aircraft manufacturing division of the General Dynamics Corporation in Fort Worth, Texas. Lockheed took over production of the F-16 and also became responsible for the existing fleet of F-111 and FB-111 aircraft.

Then in 1995 Lockheed merged with the Martin Marietta Aerospace Corporation in Marietta, Georgia, to become the Lockheed Martin Corporation and moved its corporate headquarters from Burbank, California to Bethesda,Maryland.

By the end of 2002, all EMD F-22As had flown and the design was found to be exceptional. The EMD phase continued through 2005 during which the nine EMD F-22As accrued more that 7,600 hours in the air.

The first combat-ready F-22A was delivered in 2005 and the type was declared fully operational in 2007. While the initial USAF requirement in the 1980s had been for a total of 750 operational aircraft, fleet size was trimmed over the

ABOVE First look at the Lockheed YF-22 design, in an artwork released by the USAF in 1989. Photo: USAF.

YF-22 PROTOTYPE AIR VEHICLE ONE (PAV-1) SPECIFICATIONS

CREW: One

PROPULSIVE SYSTEM: Two axial-flow, afterburning General Electric YF120-GE-100 turbofan engines of 156kN thrust

LENGTH: 19.56m

WINGSPAN: 13.11m

EMPTY WEIGHT: 15,420kg

GROSS TAKEOFF WEIGHT: 27,215kg

MAXIMUM SPEED: Mach 2 class

SERVICE CEILING: 60,000ft

MAXIMUM RANGE: 2,010km

years: to 648 in 1990, then to 339 in 1997, then to 277 in 2003, finally settling at 187 in 2008 (including four added due to aircraft losses). The 187th example was delivered in 2012 and production ceased.

Raptor squadrons were dispersed to several key air bases on both coasts of continental United States, and to New Mexico and Hawaii, and are often rotated to temporary-duty bases in Guam, Japan, South Korea and elsewhere. They also operate from test bases where their systems are constantly evaluated, updated, and repaired as needed. Armament capabilities are hardened, while possible new armaments are developed at those facilities.

During 2014-15, F-22s were first flown operationally in Syria as part of Operation Inherent Resolve. Primarily carrying out intelligence, surveillance and reconnaissance missions, they also provided close air support and attacked targets with GPS-guided bombs. In 2017, together with B-52s, they bombed Taliban-controlled targets in Afghanistan. F-22s have also been deployed to Europe on exercises and training operations.

As the F-22 is the top-of-line fighter in USAF Air Combat Command, export sales to foreign nations have been banned.

For a one-hour MIT aerodynamics lecture by an F-22 test pilot, scan the QR code.

ABOVE YF-22 number one being manufactured at the Skunk Works facility in Palmdale, California. Photo: LMSW.

F-22 EMD / F-22A SPECIFICATIONS

CREW: One

PROPULSIVE SYSTEM: Two axial-flow, afterburning General Electric YF119-PW-100 turbofan engines of 156kN thrust

LENGTH: 18.92m

WINGSPAN: 13.56m

EMPTY WEIGHT: 19,660kg

GROSS TAKEOFF WEIGHT: 37,875kg

MAXIMUM SPEED: Mach 2.25 (2,414kph)

SERVICE CEILING: 60,000ft

MAXIMUM RANGE: 2,960km (with two external fuel tanks)

LEFT YF-22 number one on an early test flight. Photo: Denny Lombard/ LMSW.

BELOW The Lockheed/Boeing/General Dynamics YF-22 (right) and Northrop/McDonnell Douglas YF-23. Photo: USAF.

F-22 FLIGHT TEST AND EVALUATION UNITS

EDWARDS AFB, CALIFORNIA: 411th Flight Test Squadron

NELLIS AFB, NEVADA: 422nd Test & Evaluation Squadron, 433rd Fighter Weapons Squadron (USAF Weapons School), Air Warfare Center

TYNDALL AFB, FLORIDA: 325th Fighter Wing, 43rd Fighter Squadron

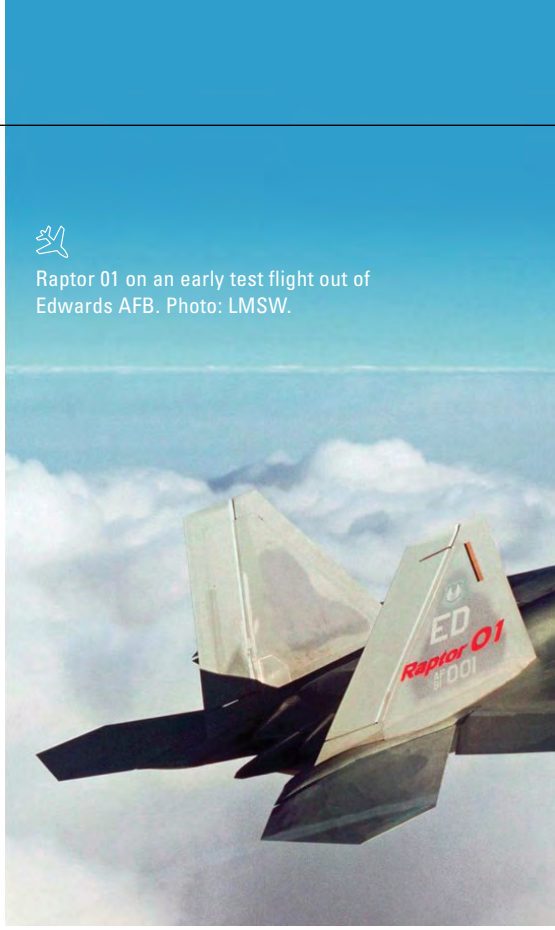
ORIGINAL F-22 COMBAT UNITS

JOINT BASE LANGLEY-USTIS, VIRGINIA: 27th and 94th Fighter Squadrons (192nd Fighter Wing, Virginia Air National Guard)

JOINT BASE ELMENDORF-RICHARDSON, ALASKA: 90th, 302nd and 525th Fighter Squadrons

HICKAM AFB, HAWAII: 199th Fighter Squadron (Air National Guard)

EGLIN AFB, FLORIDA: 95th and 301st Fighter Squadrons



Raptor 01 on an early test flight out of Edwards AFB. Photo: LMSW.

SR-72: HYPERSONIC DEMONSTRATOR AIRCRAFT

On 6 March 1990 LTCOL 'Ed' Yeilding, accompanied by Reconnaissance Systems Officer LTCOL Joseph Vida in the rear cockpit, left California in an SR-71A Blackbird of the 9th Reconnaissance Wing based at Beale AFB. Sixty-eight minutes and 2,404 statute miles later, they arrived at Dulles Field in Washington, DC. The speed record set by that flight across the United States, averaging 2,124.51mph (3,419kph or Mach 3.21), still stands. But its longevity might be in jeopardy if the so-called Son of Blackbird, the SR-72, eventually flies.

In 2013, Lockheed Martin announced that Skunk Works was developing a hypersonic demonstrator aircraft with a speed twice that of the SR-71. It was to be unmanned and fly at up to 6,440kph, or Mach 6.

"At this speed, the aircraft would be so fast an adversary would have no time to react to or hide from it" said Brad Leland, manager of the SR-72 program. "Hypersonic aircraft, coupled with hypersonic missiles, could penetrate denied airspace and strike at nearly any location across a continent in less than an hour. Speed is the next aviation advancement to counter emerging threats in the next several decades. The

Skunk Works concept for an optionally manned hypersonic reconnaissance and/or strike air vehicle. Image: LMSW.

technology would be a game-changer in-theatre, similar to how stealth is changing the battlespace today."

Skunk Works has been working with Aerojet Rocketdyne to integrate an off-the-shelf turbofan engine with a supersonic combustion, air-breathing ramjet to power the SR-72 from standstill to Mach 6.

It would not be the first hypersonic aircraft to come out of Skunk Works. In partnership with the Defense Advanced Research Projects Agency, engineers developed the rocket-launched FALCON (force application and launch from continental United States) Hypersonic Technology Vehicle 2 (HTV-2). The program collected data on three technical challenges of hypersonic flight: aerodynamics; aerothermal effects; and guidance, navigation and control.

The SR-72's design incorporates lessons learned from the HTV-2, which flew to a top speed of 21,000kph (Mach 20) and generated skin surface temperatures of nearly 2,000°C.

The planned propulsive system for the proposed SR-72 is described by Lockheed Martin as a turbine-based combined-cycle unit, integrating a modified production fighter turbine engine with a dual-mode ramjet (a scramjet, or supersonic-combustion ramjet). The turbine would power the vehicle to Mach 3, when the scramjet would take over. A common inlet would provide air to both turbine and scramjet, with the exhaust from both also exiting through a common outlet.

Variable-geometry inlet and exhaust nozzle ramps would open and close to match varying cycle requirements throughout the flight envelope.

While no specifics on the SR-72 have been released, its size and weight will most likely be similar to those of the SR-71.

In 2014, NASA released Task Order No. NNC15TA03T which "provides for a parametric design study to establish the viability of a turbine-based combined-cycle (TBCC) propulsive system consisting of several integrated combinations of near-term turbine engine solutions and a very low Mach ignition dual-mode ramjet in the SR-72 vehicle concept". The task order was issued at a firm fixed price of US$892,292.

To test the vehicle feasibility, a subscale flight research vehicle is to be created: a piloted single TBCC-engine air vehicle about 18m long – about the size of an F-22.

ABOVE Four-engine concept for the SR-72. Artwork: Luca Landino.

It is appropriate that the SR-72, if built, would follow in the footsteps of the SR-71 which remains the fastest and highest-flying military aircraft. Lockheed Martin estimates that it could be operational by 2030; whether it is used strictly for reconnaissance, as a weapons launch platform or both is unknown.

Edited excerpts and photographs are used (with permission) from **The Projects of Skunk Works** *by Steve Pace (Voyageur Press).*

For a six-minute video about the SR-72's design influence on the Darkstar aircraft in the film Top Gun: Maverick, *scan the QR code.*

SR-72 PROJECTED SPECIFICATIONS

(Figures are estimates)

CREW: None (ground-based operators)

PROPULSIVE SYSTEM: Two turbine-based combined-cycle units

MAXIMUM CRUISE SPEED: Mach 6.0 (6,440kph)

LENGTH: 30m

WINGSPAN: Unknown

EMPTY WEIGHT: Unknown

MAXIMUM TAKEOFF WEIGHT: 77t

MAXIMUM ALTITUDE: 30km

MAXIMUM RANGE: 5,300km

PAYLOAD: Intelligence, surveillance and reconnaissance systems and/or high-speed strike weapons

BIG ASPIRATIONS

FLIGHT-DYNAMICS SPECIALISTS ARE FOCUSING ON UNCREWED AERIAL SYSTEMS TO CREATE BATTLE-READY PLATFORMS IN REAL TIME.

DEFENCE SCIENTISTS ARE set to test a prototype warfare concept that aims to give war fighters the ability to respond in theatre to a detected capability gap (in their own or an adversary's force), specify requirements on the spot and then rapidly develop and produce a solution – possibly within a day.

The fourth industrial revolution has been ushered in by capabilities such as automated production, 3-D printing, augmented and virtual reality, internet of things, big data, mobile super-computing and artificial intelligence. It has seen the evolution of consumers to 'prosumers', consumers involved in the production of the items they then consume.

BATTLEFRONT PROSUMERS

To prove the value of the prosumer concept on the battlefront, flight-dynamics specialists Dr Robert Porter and Michael Young are collaborating with academia and developing prototype warfare through the prism of small, uncrewed aerial systems (UASs). Immediate benefits flowing from engagement with Australian UAS expertise will be mission-specific, responsive and agile Defence Force UAS capabilities.

"We've been involved over the years in analysing aircraft performance and flight-control systems, and also dipped our toes into aircraft design," says Dr Porter. "Lately, we've been involved with companies that are designing UASs to meet Defence needs through the Defence Innovation Hub or in response to specific Defence projects. We think small UAS platforms are a great place for Australia's defence industry to get involved."

Bespoke, crewed platforms have significant barriers to entry whereas smaller UASs are low cost and easier to test and prototype due to their lower complexity.

As Defence Science and Technology Group (DSTG) scientists have a unique, privileged understanding of Defence capability gaps and needs, it is expected they will enable the defence industry to target envisaged UAS requirements, through both expertise and, potentially, software and other tools. In addition, guiding the development of a standard Defence architecture will allow developers of drone sub-systems (such as propulsion, airframe, mission systems, and sensor and effector sub-systems) to integrate easily with compliant UAS platforms.

UNIVERSITY COLLABORATION

Dr Porter is technical lead for a new collaboration with the University of Sydney and the University of New South Wales, funded by the CSIRO's Next-Generation Graduates Emerging Technologies Program. The collaboration is recruiting 10 PhD candidates over the next year to work on relevant aspects of the prototype warfare concept.

"People on the battlefront have the best idea of their specific requirements and can identify capability gaps quicker than Defence scientists," says Dr Porter. "The dream would be for the war-fighter to specify, as a trivial example, 'My requirement for tomorrow is for a UAS to look over that hill, along the highway out to 20km and report back'. Overnight an automated digital engineering process kicks into action, selects a design from a menu of suitable options based on mission requirements, assembles it, and the war-fighter has something in their hands the next morning."

There are incremental milestones to hit before reaching that aspirational goal. The journey will start with small UASs, typically employed by soldiers from the platoon to battalion level.

DIGITAL ENGINEERING

According to Dr Dries Verstraete, University of Sydney Associate Professor in Aerospace Design and Propulsion, digital engineering can forge a future Defence Force that continually innovates and quickly adjusts to a rapidly evolving technology and threat landscape. "Digital engineering allows prototype designs to be initially proven in virtual experimentation, produced in small quantities, and quickly introduced into service," he says.

A key success factor will be a well-connected defence-industry-academia ecosystem of innovators, partners and suppliers and Dr Verstraete says the graduate program will develop the foundations of that ecosystem.

"It will demonstrate its benefits by designing, building and flight-testing various on-demand small UASs, optimised for different missions," he says.

For prototypes to be proven virtually, Dr Porter says several levels of modelling

ABOVE An Army soldier prepares to launch the Wasp uncrewed aerial system during a training activity. Photo: SGT W. Guthrie.

and simulation will be needed. "Firstly, the vehicle performance will need to be simulated in quite high fidelity," he says. "Then we need the digital environment in which to test it to show that it's going to meet the mission requirements.

"Broader than that, if the requirement is 'I need to search over that hill tomorrow', we need to simulate the physical environment, what the adversaries are doing, and the other Defence components that the vehicle will be complementing and integrating with."

Top-level systems engineering is underway to understand what will be needed for the different parts of the prosumer soldier system. The 10 PhD projects will support those needs.

While starting with simple examples, Dr Porter intends to engage with industry to help realise the ultimate war-fighter-as-prosumer goal. There may eventually be a war-fighter prosumer end-point where, rather than undertaking an engineering test campaign, a vehicle solution can immediately be used operationally, with insights fed back into the design process; developers would learn while using the vehicle. However, there are numerous regulatory and ethical considerations to consider beyond the technical feasibility.

"This is a big journey we're setting out on," says Michael Young. "But the time is ripe and there's plenty to get our teeth into. We're excited, because it's right up our alley in terms of where we want to be heading."

STAR SHOTS

DSTG Group Leader Flight Mechanics Bradley MacPherson acknowledges the prototype warfare theme is ambitious. "That is why we are teaming across DSTG through STaR Shots such as the Battle-Ready Platforms STaR Shot with universities and, to come, industry partnerships," he says. "We will have 10 PhD students from a variety of disciplines, aerospace engineering, computer science, material science, mathematics and more, working on the theme, but there is room for more. We are still looking for collaborators."

SCHOOL IN THE FINAL FRONTIER

THE SPACE TEAMS: INTERNATIONAL SPACECRAFT EXPLORATION CHALLENGE OFFERS BUDDING INTERSTELLAR EXPLORERS THE CHANCE TO GET HANDS-ON IN SPACE.

MANY PEOPLE OF A CERTAIN AGE will remember watching the Apollo missions in the 1960s and 1970s in black and white at school or seeing Space Shuttle launches in full colour on television in their living room. Children from past generations often played at being astronauts with a cardboard box helmet or flew their Millennium Falcon toy (still worth a bit if you kept the box) through the kitchen while their parents tried to cook dinner. Many of those children went on to work in the space industry. For others, it wasn't so accessible.

Fast forward to the future and school students in Australia and around the world now have the opportunity to design spacecraft, navigate to another planet, land their space vehicle, build a planetary habitat and explore a new planet to find resources to sustain human life. As if that wasn't exciting enough, they also have the opportunity to be mentored by some of the heavyweights of space exploration.

Dr Gregory Chamitoff, a former NASA astronaut, has created the opportunity for school students to explore space like never before. He has developed a collaborative platform for space systems and mission design that can be accessed remotely across the globe. Known as SpaceCRAFT, the platform provides a high-fidelity simulation of the universe, including real planetary data from NASA/Jet Propulsion Laboratory (JPL) and correct physics for models of spacecraft systems and planetary environments. A virtual reality 2D compatible space simulation environment, SpaceCRAFT is designed to enable users to collaborate, design, evaluate and experience the technology for future operations in space, effectively simulating contributions to humanity's future in space. Helped along by various industry professionals, teams of students can compete for the best mission design. It's all part of the Space Teams: International SpaceCRAFT Exploration Challenge (ISEC), presented in Australia by Space Teams partner One Giant Leap Australia.

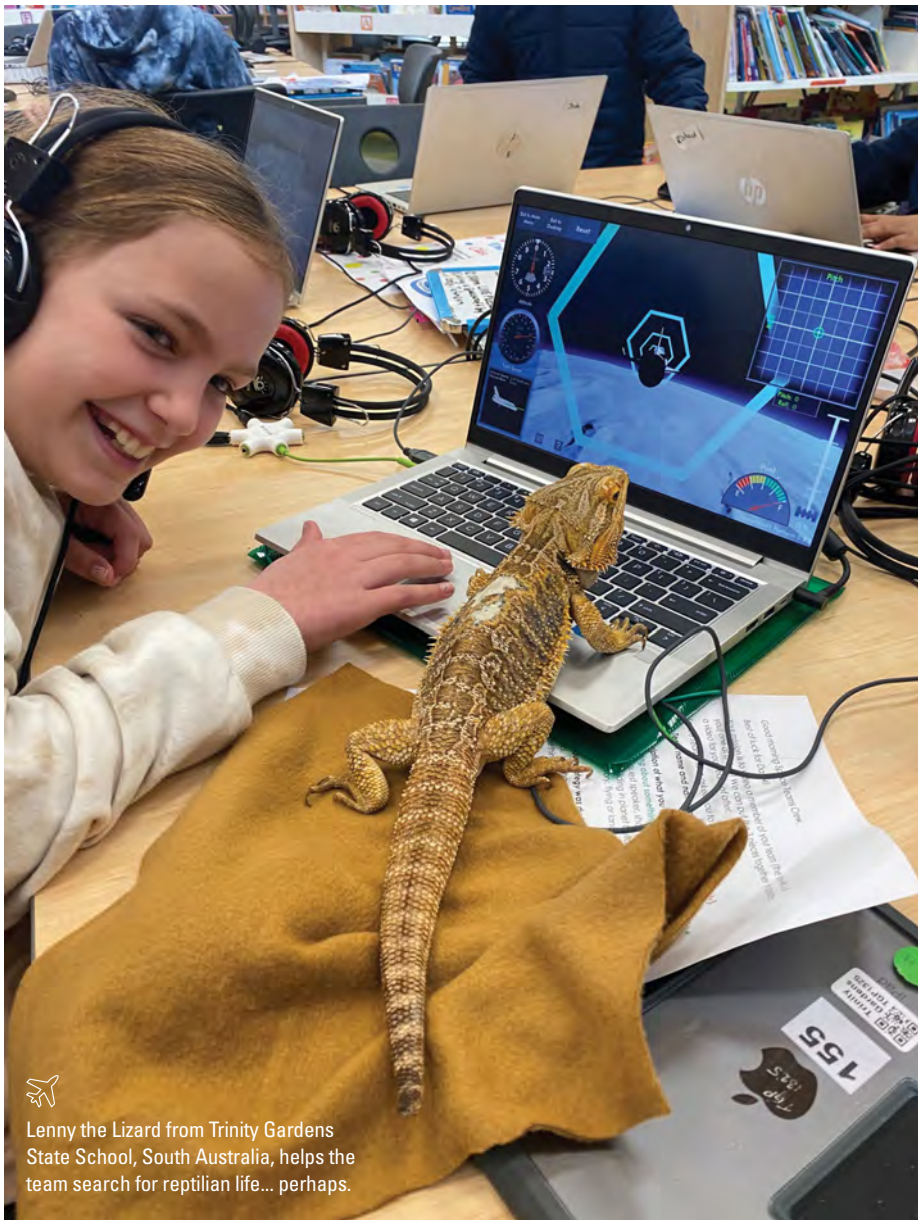
SPACECRAFT PROGRAM

The six-day program is open to students aged 12 years and up. Forming teams of two to four, budding interstellar explorers are treated to lessons on topics ranging from planetary science, orbital mechanics, and robotic exploration. Participants also learn about spacecraft systems, a subject Dr Chamitoff has literally written a book on. Through the program, those subjects bring all aspects of space exploration to an understandable level for young students who explore concepts firsthand. It aims to inspire young explorers to further pursue STEM (science, technology, engineering and maths) subjects in school and ultimately enable them to join the international community of scientists and engineers exploring the final frontier.

Dr Chamitoff has expanded the reach of his Space Teams program across the world, including the southern hemisphere where he has partnered with STEM education company One Giant Leap Australia.

The ISEC completed a mission in July 2022 with students treated to presentations from guest speakers from the space industry, such as Terry Virts, a retired NASA astronaut, International Space Station (ISS) commander and colonel in the United States Air Force. Also on hand was Gregory Johnson from Lockheed Martin, who is a former test pilot. Todd Barber, a propulsion engineer from NASA/JPL enthralled students with his experience and knowledge with an engaging presentation. Interspersed with expert talks, students developed planets, built spaceships, designed trajectories and orbits, and learned about landing their craft, habitat design and robotics.

At The Scots School in Albury, NSW students lead by science teacher Brad



Lenny the Lizard from Trinity Gardens State School, South Australia, helps the team search for reptilian life... perhaps.

Murphy were keen participants. "The world is so full of doom and gloom. However, working with these future leaders of our world I am so optimistic," said Brad. "If this is where these articulate and inquisitive minds are now, imagine what they will be doing to make the world a better place in 10, 20 or 30 years."

The students were equally enthusiastic. Kaitlyn said she loved "planet making and learning about our solar system". With collaboration and communication being a key component of interplanetary operations, Alexia enjoyed the iterative process of experiments, refining the various rocket designs while keeping in constant communication with team members.

It wasn't all smooth sailing though, as always in space there were obstacles. "It was hard to get my planet to the Vulcan orbit," said Vinul, while Alexia "found it hard to get sustainability".

Students enjoyed the new group collaboration feature of the spacecraft builder. They found the orbital trajectory fun and "with a couple of new ideas" managed to get a high score on it. The planet builder was also entertaining – "experimenting with what makes the planet look more alien-like and stuff like that". Zara loved combining fuel and the engine, but "something I found hard was to balance the food and water ratio so I could get indefinitely on all of the tasks".

FACE-TO-FACE

In collaboration with the Royal Melbourne Institute of Technology (RMIT), One Giant Leap was able to offer 16 students the opportunity to take part in the International SpaceCRAFT Exploration Challenge in person at RMIT's Space Hub. With

the assistance of STEM undergraduate students, the enthusiastic space explorers of the future were able to gain practical experience with the Space Teams platform. Year 8 Student Alison reflected on the experience: "The hardest part was definitely landing our spacecraft. You had to consider the altitude, airspeed, fuel and precision. In this mission, fuel was extremely scarce, and it took us hours upon hours of work to finally land our spacecraft. The program was extremely hard, as we had to work in a team to design spacecraft, plan orbital trajectories, land our spacecraft, build a habitat, and more. That required us to learn about different engines, fuel, orbital mechanics, the principles of flight, energy conservation, sustainability of resources, and, of course, teamwork."

STUDENT ENTHUSIASM

One Giant Leap Australia Director Jackie Carpenter said the enthusiasm around the experience was incredible. "Students, whose parents apparently can't normally get them out of bed for school, were turning up two hours early!"

Manuel, from Year 8, said, "my heart skipped a beat when I was told I was selected for the program", while Sienna, also Year 8, was "ecstatic" to be selected. "It has been such a rewarding program that I know will help me for years to come," she said.

Xinqun, Year 8, said: "When I found out that I was chosen for the SpaceCRAFT Exploration Challenge, I was overjoyed. I was sure it would help strengthen my leadership and teamwork skills that will be more than helpful later in life."

"That was such a common reaction from the incredible students", says Jackie. "The way they tackled the challenge head-on was extraordinary and there were challenges, the program is not an easy ride, but through collaboration and tenacity, these leaders of the future excelled."

As Rushil, Year 8, said: "We ran into many issues [and] overcame them with determination. The orbital descent requires large amounts of precision and concentration and the spacecraft builder [teaches] you to be creative, to be able to adapt."

Dr Chamitoff is as enthusiastic about the virtual space missions as he was about the real thing. "The latest International SpaceCRAFT Challenge has been a wonderful success, with students all around the globe coming together after what has been a difficult time for students everywhere," he said.

Dr Chamitoff attributes much of the success of the Australian missions to the work of One Giant Leap Australia and RMIT. "It just shows what can be achieved as we forge a new generation of space explorers," he said. "The best assessment though is the feedback from the students themselves."

Year 8 student Alison said she "worked on it all night every night on a FaceTime call with my teammates because we were so invested in it… the worst thing about the program was when it ended! I woke up super early on Sunday excited to go to RMIT until I realised it was over."

To find out about the next Space Teams: International SpaceCRAFT Exploration Challenge contact jackie@onegiantleapaustralia.com for details.

"THE ORBITAL DESCENT REQUIRES LARGE AMOUNTS OF PRECISION AND CONCENTRATION."

YEAR 8 STUDENT RUSHIL

TOP Students were offered the opportunity from One Giant Leap Australia to attend RMIT in Melbourne to take part in the challenge.

ABOVE LEFT Dr Gregory Chamitoff briefs students around the world for their missions.

The Scots School science teacher Brad Murphy ready to teach a lessons on space exploration.

WORDS Michael Nelmes | **IMAGES** Australian War Memorial

DETECT, DEFEND, ATTACK

JAPANESE AIR RAIDS ON DARWIN IN 1942 PROMPTED A RAPID PROGRAM OF AIRFIELD CONSTRUCTION OR UPGRADES IN THE NORTHERN TERRITORY.

TODAY THE NORTHERN TERRITORY is host to RAAF Bases Darwin and Tindal. Tindal, originally an unused World War II airfield called Carson's, was opened in 1989. Its present name commemorates WGCDR Archie Tindal who was killed during the first Japanese air raid on Darwin on 19 February 1942.

Darwin's first airfield, at Fannie Bay, was established in 1919 for the competitors flying from England in the Great Air Race. From that time onwards, it was the first Australian landfall for aircraft arriving from overseas via the north and north-west.

Japanese and German military expansions of the 1930s prompted a focus on Darwin as an air base for the defence of Australia. On the recommendation of the Chief of General Staff, Major General John Lavarack, it was resolved that a RAAF station should be built and a site at Parap, just east of the existing civil aerodrome, was selected. The first military personnel arrived at the uncompleted aerodrome in July 1939 and, a year later, RAAF Station Darwin and No.13 Squadron were formed from elements of No.12 Squadron.

A few other airfields in the Territory had been established by the time of the first Japanese raid on Darwin. But the attack, and the need to strike back, prompted a prodigious program of airfield construction or upgrades in Australia's top end. Those airfields were used throughout the war by both RAAF and US Army Air Force (USAAF) units, plus a few squadrons of the Royal Air Force (RAF) and Netherlands East Indies (NEI) under RAAF control.

In all, 64 Japanese raids on the NT are recorded, the majority on Darwin and its vicinity. Forty Japanese reconnaissance missions were also recorded.

Fighters (Kittyhawks, Spitfires and Boomerangs) flew in defence of Darwin and the region's airfields from the RAAF station and from small airstrips to its south. Bombers (Fortresses, Liberators, Mitchells, Hudsons, Beauforts, Venturas and Marauders) generally needed larger airfield complexes, preferably with two sealed runways. Strike and reconnaissance aircraft (Beaufighters, Mosquitoes and others) were also crucial to the war effort, as were the long-range Catalina flying boats stationed in harbours. In 1944, many units began moving north from the Territory to the islands as the war moved north and the defence of Darwin became less pressing.

Some 80 wartime airfields were established in the Territory, including emergency landing grounds and a few strips that were never completed, under the control of North-West Area Command. Of those, the 21 airfields that were home to squadrons or flights are listed on the opposite page.

RADAR STATIONS

The Battle of Britain in 1940 had demonstrated the importance of an effective chain of radar stations to detect and warn of incoming enemy aircraft.

In October 1941, Australia's War Cabinet directed a committee to look into establishing a long-range warning system for Australia. The committee recommended a chain of RAAF-operated warning stations at 26 locations around the Australian and New Guinea coastlines, with Darwin a priority. The plan was accepted a month before the Pacific War began, and Wing Commander A.G. Pither was appointed to head its implementation.

The first operational RAAF radar station, a permanent building which still stands today, was established at Shepherd's Hill, NSW, in January 1942, and a RAAF radar school was established at Richmond, NSW.

Radar or RDF (radio direction finding) stations were intended to work in co-operation with RAAF coast watchers, who were initially stationed at Bathurst Island and Port Keats and reported by radio to No.5 Fighter Sector, established at Sandfly Gully, south of Darwin, and later relocated to Berrimah.

The ubiquitous Light Weight Air Warning (LW/AW) radar station introduced in late 1942 was a light-weight, air-transportable facility produced by NSW Government Railways. At its core was an air warning transmitter and receiver developed by the Radiophysics Division of the Council for Scientific and Industrial Research (CSIR) at the University of Sydney. A total of 56 were made and distributed to 117 sites.

A radar team could assemble a LW/AW station at a remote site in a few hours. Operators sat with the sets on a hand-rotated turntable mounted beneath a canvas shelter. The antenna rotated above the 'control station'. While the previous design for a ground station weighted 12t and was still considered transportable, the LW/AW weighed less than 3t. An example can be seen in the Australian War Memorial's Aircraft Hall.

Darwin's No.31 Radar Station at

NT RADAR STATIONS

(Station numbers in brackets)

59 Mile *(60, 161, 344)*
Adelaide River *(150, 161, 321, 109)*
Berrimah
Batchelor Airfield *(317, 308, 318)*
Bathurst Island *(38)*
Cape Arnhem, Yirrkala *(321)*
Cape Don *(318, 46)*
Cape van Diemen, Melville Island *(318, 80, 60)*
Darwin *(38, 39, 351, 307/61, 150, 161, 162, 302, 308, 309, 3440)*, Dripstone Caves *(31/310)*, Point Charles *(105)*, Nightcliff *(109)*, Old Southport Road *(224)*, Casuarina *(257)*
Fenton Airfield *(31, 309, 319)*
Goulburn Island *(309)*
Knuckey's Lagoon *(132, 162, 150)*
Lee Point *(59)*
Milingimbi Airfield *(308, 321)*
Mt Woods *(109)*
Peron Island *(307/61)*
Port Keats *(39)*
Sattler Airfield *(310, 343, 352, 161)*
Strauss Airfield *(343)*
Wessel Island *(312)*

ABOVE 457SQN RAAF ground staff at Livingstone, NT.

BELOW A RAAF LW/AW radar station.

ABOVE Manbulloo Airfield, November 1943. The first RAAF B-24 bomber missions were flown from here in July 1944.

BELOW RAAF Liberators at Fenton, NT.

Dripstone Caves began arriving on 4 February 1942, a fortnight before the Japanese attack of 19 February, but due to a lack of lifting equipment, power supply and tools, it was not operational before the raid. The warning that day came instead from visual sightings at Bathurst Island, however, the warning was not acted upon.

On the day that Darwin's radar became operational, 22 March, the rudimentary station detected another incoming Japanese raid. That time nine Timor-based Betty bombers were heading south for Katherine, where they bombed the airfield – the furthest inland strike by Japanese aircraft. Later, some stations were used in conjunction with anti-aircraft defences.

From 1943 onwards, the stations came under control of No.44 Radar Wing RAAF at Adelaide River. Over the course of the war some 27 radar stations were established in the NT, some of which bore the brunt of detecting the enemy onslaught.

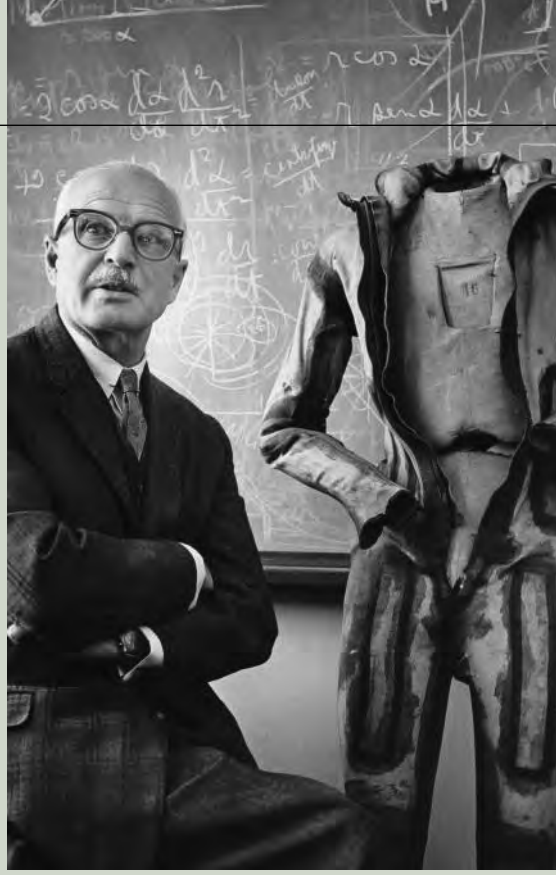
NT AIRFIELDS & THEIR MAJOR OPERATIONAL UNITS, 1942-45

AIRFIELD	UNITS (RAAF UNLESS SPECIFIED)
Adelaide River	8th SQN USAAF
Batchelor	2SQN, 6 Communications Unit, 12SQN, 18SQN NEI, 7th & 9th SQNS USAAF, 19th Bomb Group USAAF
Coomalie Creek	1 Photographic Reconnaissance Unit, 31SQN
Daly Waters	2SQN, 13SQN
Darwin Civil	12SQN, 54SQN, 548SQN, 549SQN RAF
Darwin RAAF	2SQN, 12SQN, 13SQN, 21SQN, 54SQN RAF; 528th, 529th, 530th SQNS USAAF
Doctors Gully (flying boat)	20SQN, 43SQN, 112 Air-Sea Rescue Flight
Fenton	21SQN, 24SQN; 319th, 528th, 530th SQNS USAAF
Gould	1SQN
Gove	13SQN, 83SQN
Hughes	1 Photo. Reconnaissance Unit, 2SQN, 13SQN
Livingstone	77SQN, 457SQN, 54SQN, 548SQN RAF; 9th SQN USAAF
Long	23SQN; 529th, 531st SQN USAAF
Manbulloo	6 Comm. Unit; 529th, 531st SQN USAAF
McDonald	18SQN NEI
Melville Bay(flying boat)	42SQN
Milingimbi	83SQN
Pell	12SQN
Sattler	452SQN, 457SQN
Strauss	76SQN, 452SQN; 549SQN RAF; 8th SQN USAAF
Manbulloo	6 Comm. Unit; 529th, 531st SQN USAAF

Source: Darwin's Air War *by Bob Alford.*

SPIN DOCTOR

DEVELOPING AND DEFLATING THE AUSTRALIAN ANTI-G SUIT.



ON 13 APRIL 1942, a pilot encumbered by a heavy rubber suit clambered into what had formerly been Prime Minister Robert Menzies's 'private plane', gifted personally to him by the British Government. The prime minister had readily transferred the Hawker Hurricane, Mk.I V7476, to the RAAF. The anti-g flying suit being air-tested for the first time, however, required far more complex negotiations, which began with a flash of inspiration by University of Sydney physiologist Dr Frank Cotton.

ORIGINS

World War II is often portrayed as a battle between boffins, in which novel scientific and technological insights not only solved pressing problems, but generated new operational opportunities. Examples ranged from radar to rockets, nuclear weapons to penicillin, electronic computing to *schnorchels* permitting submarines to remain submerged indefinitely.

One Allied technical success – unmatched by German, Japanese or Italian research – was flying suits that helped prevent pilots from blacking out (momentary loss of sight) during tight turns or recovering from steep dive-bombing attacks.

In the two years after the European war began in September 1939, such suits were developed quite independently in the USA, Canada and Australia. An unanticipated conjunction of events drew the threads together on the day the Pacific War commenced.

Arriving in Washington DC on 8 December 1941, just hours after news of the Japanese raid on Pearl Harbor, 'Frankie' Cotton stepped into a new world of possibilities. He was no stranger to America, having enjoyed a Rockefeller Travelling Fellowship in Cleveland over 1932–34.

As one of the first Senior Research Fellows supported by the newly formed National Health & Medical Research Council (NH&MRC) in 1937, he was among only a handful of promising Australian medical scientists to be funded by the Commonwealth as the Great Depression receded and the prospect of a new war loomed.

It was Cotton's expertise – and his intuition as to how it might help win the war – that had brought him back to North America. A specialist on the human cardiovascular system, his doctoral thesis had investigated changes in the body's centre of gravity in the sports-science context. Reading that blackout was proving a significant problem in the wheeling dogfights above the embattled British Isles in the early months of the war, he suddenly envisioned how the problem might be overcome. Within days, Cotton was seeking support from the University of Sydney, the NH&MRC and the RAAF to develop his invention: an inflatable anti-blackout suit.

From the outset, however, Cotton's project required instigating two quite distinct, but interrelated, initiatives. The first was the flying suit, the second, a human centrifuge in which to evaluate the suit. Both would prove equally effective in stymying Cotton's hopes of producing an item of operational equipment to hasten the Allied triumph.

PERFORMANCE UNDER PRESSURE

Cotton's most important idea was the pressure gradient. When an aircraft turns at high speed, the associated centrifugal force drains blood from the pilot's head and chest into their abdomen and legs. Measured in multiples of the normal acceleration due to gravity (g), a force of 5g can within seconds lead to a greying of vision, then a total loss of sight, blackout, before producing unconsciousness. Pilots able to withstand high g for a few more seconds, or at a greater acceleration, could potentially outmanoeuvre opponents to deadly effect.

Cotton's logic was to counter the blood displacement process by creating a gradient of pressure from the feet up to the ribcage. By fitting pilots with a tight suit that inflated according to the

amount of g experienced, the greatest counter-pressure was applied in the boots, gradually lessening up the legs and being least in the midriff. The effect was to squeeze blood back toward the heart and brain, where it was most needed. That was the principle Cotton's small team worked on from September 1940 until 21 November 1941, when he set off to exchange research with colleagues in Canada, the USA and the UK. As letters he received in 1945 from senior aviation medicine figures attested, it was also considered his most valuable contribution to the Allied war effort.

Indeed, it could be argued that Cotton's North American visit in 1941 represented the high point of his research program. In Toronto, he met with Canadian medical scientist Wilbur 'Bill' Franks, who had been exploring the same problem since 1938. Franks also advocated a tight rubber suit, albeit one filled with approximately two gallons [9 litres] of water. As the g level rose, both the pilot's blood and the water were forced toward his feet. Because the outfit could not expand, the water compressed the lower body, returning blood to the torso and head. Flight tests confirmed that the hydrodynamic suit increased blackout threshold by about 2g.

By late 1941, Franks oversaw the world's most sophisticated human centrifuge, funded by the Royal Canadian Air Force. More importantly for Cotton, the Franks Flying Suit was just entering production at the Dunlop factory in Manchester for use by Britain's Fleet Air Arm, and used sporadically by pilots flying off aircraft carriers from 1942 onwards. Although Cotton's inflatable prototype

ABOVE & LEFT Hurricane V7476.

OPPOSITE PAGE Canadian Wilbur Franks with his uncomfortable water-filled anti-g suit, the first to be used in combat. Photo: University of Toronto Archives.

LEFT Dr Cotton (centre in hat) and FLTLT K.V. Robertson in a CAAG suit with others involved in developing the anti-g suit, just after the first successful test flight in the only Hurricane brought to Australia.

offered greater protection, up to 9g, the Canadian had stolen his march, even if one British pilot complained: "I hated the Franks suit. It was cold and clammy and always made me want to piddle after half an hour's flying".

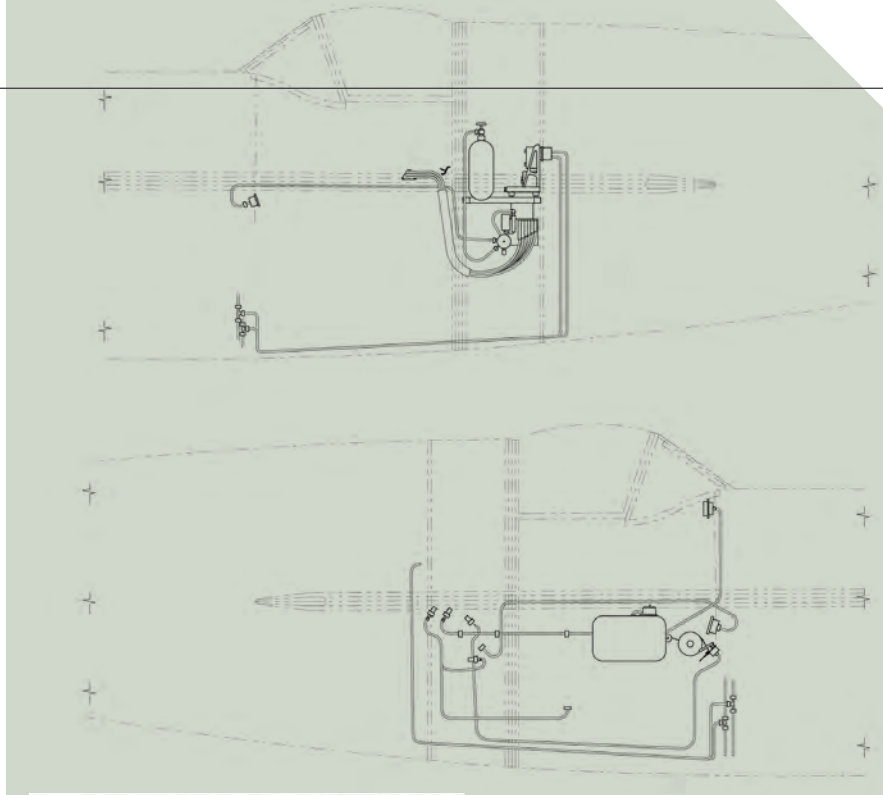
In America, Cotton conferred with a US naval flight surgeon, John 'Jack' Poppen, who had been developing a rather ineffective constrictive waist belt to stop dive-bomber pilots blacking out. In evaluating several new competing designs for inflatable suits, Poppen immediately saw the potential offered by Cotton's gradient pressure principle and urged its application to subsequent American developments. As a result, from 1943, both US Army Air Force and US Navy fighter pilots received early model g-suits that worked along Cotton's lines. By mid-1944, however, the pressure gradient principle was dropped in favour of a simpler, lighter, single-pressure system.

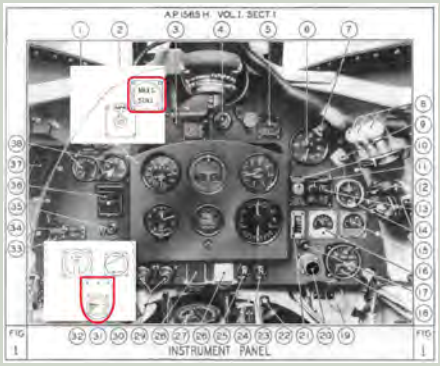
While American Air Force units were ambivalent about the combat value of anti-blackout suits over Europe, and were expressly forbidden from using them in the Pacific, US naval aviators proved enthusiastic converts. They claimed that g-suits improved their victory tallies and also reduced the physical fatigue that often drained pilots after dogfighting. Although perhaps overstating the case, Yale University physiologist John Fulton claimed, in 1948, that "our fighters with their anti-g suits were able to completely out-manoeuvre German fighters during the last months of the war and in that way they effectively shortened the conflict".

ZEROS & ZIPPERS

In Australia, however, Cotton faced an uphill battle. Returning from Britain early in 1942, he just skirted the fall of Singapore but was caught in Darwin on the day it was first bombed, 19 February 1942. Buoyed by his reception in America, and by British encouragement to develop his work as a backup to the Franks suit, Cotton now found the RAAF scrambling for modern fighters to defend the continent's north.

As American Kittyhawks and British Spitfires gradually made their way to the Northern Territory over 1942-43, it soon became apparent that they were outmanoeuvred by front-line Japanese fighters such as the Mitsubishi 'Zeke' (or 'Zero') and Nakajima 'Oscar'. Here was the opportunity for the recently christened Cotton Aerodynamic Anti-G (CAAG) suit to make a meaningful difference.





ABOVE Diagram of the Spitfire plumbing installation to provide the CAAG suit's inflation. Image: author.

LEFT CAAG suit additional instruments in a Spitfire Mk.VIII. Image: author.

Sadly, it was not to be. Post-war evaluation of the operational failure of the CAAG program, failed to identify a single 'smoking gun'. While the obstacles were often independent, their effect was cumulative. Cotton's extensive papers in the University of Sydney Archives tell part of the story, especially when matched against corresponding NH&MRC and RAAF files from the National Archives of Australia. Another critical clue lies in the many fragments of experimental and operational CAAG suits held at the University of Sydney's Macleay Museum, where they have been preserved since discovery during renovations of the Old Medical School in the mid-1990s.

Indeed, some of the most mundane problems were material. Developing from scratch a flying suit that would tightly fit each pilot's body, then inflate progressively to counteract dynamic g-levels almost instantaneously, was no simple matter. When the first prototypes created by Hardy Brothers failed miserably, Cotton turned to Dunlop Perdriau, whose master rubber technician, J Kelly, soon became a critical member of the team. Gradually, suits were produced by surrounding an inner silk lining with inflatable bladders and dipping the outfit multiple times in latex. Each suit had to be handmade, then individually tested in Cotton's centrifuge both for effectiveness and durability. As repairs in the surviving suit elements confirm, it was not uncommon for them to burst.

Zippers were also enormously problematic. Only a relatively new technology, zips were essential to allow pilots to rapidly don and doff CAAG suits. But wartime Australian zips tended to fail on test, effectively writing off the entire suit, while supplies of more robust Canadian alternatives were repeatedly held up. As a result, validating the design specifications and manufacture

ABOVE Climbing into a RAAF Mustang for a test flight.

ABOVE Testing the CAAG suit in the centrifuge.

of Cotton's suit were delayed through the critical months of late 1942 and early 1943.

A parallel problem afflicted the air distribution network designed to both supply the correct air pressure to inflate the suit's pressure-gradient compartments and to then deflate them when the need had passed. Although a fine-tolerance valve was later designed by engineer David Myers at the National Standards Laboratory, each had to be repeatedly tested in the centrifuge for reliability. In February 1944, the RAAF withdrew its order from the first manufacturer after 18 months of exasperating failures. During an air test in Britain, one device malfunctioned and the "whole suit was blown up to the highest pressure"; the "pain of nearly 30 pounds of pressure to every square inch over nearly the whole of his body" almost caused the alarmed pilot to crash.

ZOOT SUITS

By May 1943 the CAAG suit and ancillary equipment had reached a critical point of reliability. Chief of the Air Staff George Jones ordered 100 suits and declared it the RAAF's "absolute top priority" to fit the equipment to front-line Spitfire, Kittyhawk and Australian-made Boomerang fighters. It wasn't simply a case of shipping the suits to squadrons. Each aircraft had to be fitted with a pressurised carbon dioxide supply and regulator valve, plus a combination of lights, buzzers and horns to warn pilots that they were either pulling more g than their aircraft could withstand, or turning so tightly that they risked stalling and losing control. In the end only Spitfires were fitted.

As those elements began to come together, coordinated especially by George Ellis at the RAAF's Directorate of Technical Services, Cotton and several colleagues took the suit to Darwin for a field test with No.452 Squadron. At first deeply suspicious, Spitfire pilots were gradually won over, especially by Cotton's long-term test pilot, Ken Robertson. Immediately labelling it the 'zoot suit', most flyers who tried the CAAG equipment agreed that it might just give them the edge they were seeking. With Jones' endorsement, by early September 1943 the entire Squadron was fully equipped.

Dr Peter Hobbins (Department Of History, University Of Sydney).

Versions of this article first appeared in Record, *the University of Sydney Archives magazine 2015, and* Aviation Heritage, *the journal of the Aviation Historical Society of Australia Inc. (June 2017). Photos: Australian War Memorial unless otherwise stated.*

See next edition for part II.

THROUGH ADVERSITY TO SUCCESS

FROM ITS ORIGINS AS A HOME FOR A RETIRED CANBERRA BOMBER, THE QUEENSLAND AIR MUSEUM HAS GROWN TO COVER A TWO-HECTARE SITE DISPLAYING 79 MILITARY AND CIVIL AIRCRAFT.

WORDS
Christopher Rees

WHEN MEMBERS OF THE QUEENSLAND BRANCH of the Aviation Historical Society of Australia purchased their first aircraft, a GAF Canberra Mk20 bomber (serial A84-225), it proved to be the start of a project that created Australia's most diverse display of historic aircraft.

In December 1973, a small committee was formed to explore the possibility of establishing an air museum in Queensland. Resolving to preserve Australia's aviation heritage, their commitment to the cause hardened when it was realised that, apart from a few local collectors, Queensland did not have an aviation museum.

The journey the small cadre of volunteers were about to begin would throw up many challenges – financial, physical and bureaucratic. The first hurdle though, was where to house the Canberra.

A headline in the local *Courier Mail* newspaper, 'Bomber with nowhere to go', sparked keen local interest. A week later the committee was offered a spot in a museum of horse-drawn vehicles, located at Pioneer Valley Park in the southern Brisbane suburb of Kuraby.

A period of upheaval followed, and the bomber was moved to a leased site at Lower Nudgee near Brisbane Airport. There the collection was expanded to include a Gloster Meteor TT20 jet trainer (Serial WD647, TT - Target Towing equipped), two Sea Venom jet fighters (serials WZ910 and WZ898) and a disassembled Vampire jet (serial A79-828).

Brisbane Airport development forced a temporary relocation of the exhibits to a holding site on the airport grounds, where a de Havilland Drover airliner (registration VH-FDR) was added to the collection.

In 1983, the Canberra bomber was the subject of a bizarre extortion attempt. A home-made projectile was fired at it to demonstrate a threat to Trans Australia Airlines (TAA): a TAA airliner would be next if the perpetrator's demands weren't met. The only damage to the Canberra was a small gash to a bomb bay door.

The threat was never carried out.

The museum's stay at the airport was short due to high rent. After much publicity, the best offer came from the Landsborough Shire Council and a purpose-built hangar at Caloundra Airport, 90km north of Brisbane. In June 1986, the aircraft were transported there, no simple task, and the hangar was officially opened the following April.

From rather inauspicious beginnings, the cadre of enthusiasts and volunteers had survived a nomadic existence and many setbacks, but the future looked promising with six aircraft exhibits, some incomplete but enough for the museum to be taken seriously as a going concern.

Following the original plan to rescue mainly retired or written-off military and civilian aircraft, an ambitious expansion program commenced. Some acquisitions needed more work than others, indeed some were only fuselages without flying surfaces.

THE SENTOSA RESCUE

In 1989, undeterred by the potential effort involved, six intrepid volunteers set out to undertake a most challenging rescue mission. They travelled to Sentosa Island, Singapore, to transfer to Australia three British jet fighters – a Sea Vixen, Meteor and Hunter, that were about to be meet their end in a scrapyard. What could possibly go wrong?

The omens were not good when the group arrived at their hostel on Sentosa Island, the food outlets were closed, the accommodation was *sans* drinking cups and dunny paper, and the first of many thunderstorms hit. During their month-long mission, illness, injury, a diet of spam sandwiches and a ferryman who barred them from transporting their tools were overcome. To disassemble the aircraft for transport, they removed thousands of corroded bolts and screws and made countless visits to the hardware store. A broken truck axle, limited road access, heavy rain, unexpected costs, traffic jams and government bureaucracy all made for an eventful expedition.

Those trials and tribulations were rewarded five months later, when two containers arrived at Caloundra. The painstaking task of putting the aircraft back together could then begin.

OTHER 'LOST CAUSES'

Since that first eventful expedition, museum volunteers have carried out no less than 30 recovery missions. While the Sentosa aircraft were essentially complete, some later recoveries required more imagination than others to envisage the subject aircraft as a potential exhibit.

The recovery of a World War II PV-1 Ventura bomber fuselage (serial A59-96) from a New South Wales farm posed different challenges. Declared surplus in 1948, it had found a new lease of life as a store for silage and animal feed, but even in that state it had been acquired by a private collector.

In 1991, the museum acquired the fuselage from Chewing Gum Field Aircraft Museum at Tallebudgera, near Coolangatta. Once at Caloundra, the daunting project to rebuild the aircraft into a complete Ventura began.

Museum volunteers are a resourceful bunch, and parts were recovered from wherever they could be found. Some

ABOVE RAAF Winjeel trainer A85-410, before and after restoration. Behind the restored Winjeel is the de Havilland Dove of Mandated Airlines, with a DC-3 of Airlines of NSW. Photos: Nick Sayer.

OPPOSITE PAGE RAAF Lockheed Neptune anti-submarine aircraft A9-760 during assembly.

ABOVE Lockheed Ventura fuselage A59-96 as delivered… and restored. Photos: Ian McDonnell

LEFT Fairchild Metro II airliner VH-BPV. Photo: Ron Cuskelly.

LEFT RAAF Canberra bomber A84-225. Photo: Ron Cuskelly.

parts had to be modified to Ventura design, such as a Hudson bomber's tailplane recovered from a salt marsh where it had lain for 50 years. The Ventura is still a work-in-progress, and currently the sole example now displayed in Australia (the RAAF Museum's Ventura being in storage, awaiting repairs).

The Ventura is one of several RAAF anti-submarine reconnaissance aircraft on display. Another, the Neptune, was brought from a museum near Mareeba and occupied a team of 14 volunteers on-site for eight days. The fuselage had to be disassembled into four sections to fit onto trucks without the need for a police escort while in transit.

More than 20 of the aircraft on display have been recovered from sites around Australia, each one requiring a team of volunteers to dismantle it and arrange for shipping to the museum site. Most would otherwise have been scrapped or buried.

VOLUNTEERS & STORIES

In any not-for-profit museum, it is the volunteers who make the organisation a success, and Queensland Air Museum is no exception. Their enthusiasm is infectious and, as most of the aircraft have had a long service life, the museum guides and workshop volunteers are not short of interesting stories to tell.

During its service life, the Mirage fighter on display survived a wheels-up landing at Tullamarine, Melbourne in October 1974. Or should we say, the pilot, at least, survived.

The Douglas DC-3 was one of three aircraft that flew in formation under the Sydney Harbour Bridge on 14 May 1942 – a protest by KNILM (Royal Dutch Indies Airways) crews against the wartime sale of their aircraft to the US Army Air Force. That exhibition was some 18 months before the same feat was performed by a RAAF Lancaster bomber.

A little-known Neptune story, as recalled by QAM volunteer WGCDR (ret'd) Phil Andrews (a RAAF Air Electronics Officer), occurred in 1964. The aircraft was on an ANZUS exercise in Hawaii when the observer in the nose noticed something on the horizon. Dropping down from 8,000 feet for a closer look, the crew recognised a submarine.

Busily running through their briefing notes, they could find no indication of an out-of-action submarine heading for Pearl Harbor. As far as the Neptune crew were

TOP RAAF Lockheed Neptune anti-submarine aircraft A9-760, as delivered.

ABOVE The Neptune's centre section.

concerned, it was fair game. They opened the bomb bay doors and made a mock attack, signalling the attack with practise depth charges.

On return to base, they were met by a stern-looking Operations Officer who asked whether they were trying to restart World War II in the Pacific. The submarine, it turned out, was from the Japanese Self Defence Force, on a good-will mission to Pearl Harbor, and its captain was not happy.

Thinking on their feet, the crew rushed down to the port armed with crates of beer. Meeting the Japanese captain and crew, they explained apologetically what had happened. It seems the captain accepted the crew's apology and the 'VB diplomacy'.

THE DISPLAYS

At last count the museum's two-hectare site displays 79 military and civil aircraft – a cross-section of fighters, bombers, maritime surveillance, general purpose, transport, executive and helicopters. In addition are some 30 aero engines of various types, including inline and radial piston engines and early and modern jet engines.

Renovation work is carried out in well-equipped workshops by multi-skilled volunteers. The work follows a pre-planned program determined by the condition of each item, with many requiring significant work to bring them up to display standard.

From its small beginnings, the museum has successfully adhered to its policy of selective acquisition. The museum committee would put it more succinctly: Have we got one? Do we need a better one? Where can we put it?

Recently retired aircraft, of course, arrive in more complete form. The museum proudly displays one of

ABOVE RAAF Aermacchi MB-326 trainer. Photo: Angelo Calleja.

only a dozen F-111s on show around Australia. In keeping with the bomber theme, there is an unequalled tribute to Air Vice-Marshal Don Bennett, the Queenslander who formed RAF Bomber Command's Pathfinder Force. The special air-conditioned exhibition room contains original documentation and furniture not displayed anywhere else.

DEVELOPING THE MUSEUM

The museum's original objective, to preserve Australia's aviation heritage, is as true today as it was at inception. Building up a large and diverse collection has been key to its success. But the museum recognises the competition posed by other tourist attractions and has a policy of surveying its visitors to evaluate the activities they would like to experience and the exhibits that would see them return.

Many want more interactive exhibits, such as virtual-reality experiences and simulators. Those initiatives are in future plans, as are a new display hangar, upgraded workshop facilities, a food outlet and a visitor centre based on providing STEM (science, technology, engineering and mathematics) education opportunities.

Having overcome adversity and challenges on its journey since 1974, Queensland Air Museum is well placed to continue developing so that visitors of all ages can embrace and appreciate aviation history and the impressive evolution of the aerospace endeavour.

• Queensland Air Museum, 7 Pathfinder Drive, Caloundra Airport. Open daily, except Christmas Day and Good Friday, 10am to 4pm. Entry is $20 adult / $15 concession / $10 child / $40 family. For a full aircraft inventory with photos, detailed histories and stories, visit qam.com.au.

Some information for this article was taken from the Vision v Survival 1992 *paper by Ron Cuskelly, QAM.*

RAAF Lockheed P-3 Orion fuselage being trestled for assembly.

The Orion during assembly…

…and on display.

Moorebank Squadron enjoying a flying day at the League's Air Activities Centre, Camden Airport.

77 YEARS OF SERVICE

EARLIER THIS YEAR the Returned & Services League of Australia (RSL) honoured Commissioner Raymond Claude Bell OAM of the Australian Air League (AAL) with the 2022 RSL Anzac of the Year Award. Commissioner Bell was honoured in recognition of more than 75 years ongoing commitment to the Air League, over 50 years voluntary service as a band marshal at the Sydney Anzac Day March, and his long service to the Air Force Association (NSW Division).

Ray Bell joined the AAL as a young cadet at the Marrickville Company, NSW in November 1944.

He was associated with the Marrickville Company for many years and went on to be the Company Officer Commanding during the 1950s. During that time, he was instrumental in the construction of the company's hall at Warne Place, which had originally been built as a US Navy PT Boat service workshop at the Rose Bay Flying Boat Base during the war and later relocated to Marrickville.

Ray took part in the 1954 royal tour when the Air League was among several groups to provide a guard of honour to Her Majesty Queen Elizabeth II at Katoomba.

He recalls the Duke of Edinburgh saying to one of his cadets who was a little unsteady with his flag as the royal car drove past, "Don't drop that bloody flag son". As the event was on a workday, Ray had called in sick and didn't think anything of it until the following day when a photo of him saluting the Queen was splashed across the front page of a Sydney newspaper. When his boss asked about the matter, Raymond replied, "I believe the Queen is a little more important than work".

In 1956, the AAL was reorganised with units designated as squadrons and in 1960, the Marrickville Squadron purchased a surplus Fairey Firefly MK VI (Serial Number RN WH632). That aircraft was later sold to the Camden Museum of Aviation and now resides at the Canadian Warplane Heritage Museum, Mt Hope, Canada in flying condition.

In 1968, Raymond was appointed Group Field Commissioner for NSW Boys Group, a position he held until 1984 when he was appointed Group Executive Commissioner for NSW Boys Group.

Ray lead the NSW Boys Group for 34 years, during which time he helped established the Air League's Air Activities Centre at Camden Airport. The centre is staffed solely by volunteers and is the only volunteer operation of its type in Australia. On 26 January 1995, Ray was honoured with the award of the Medal of the Order of Australia in recognition of service to youth, particularly through the AAL.

Having recently celebrated his 90th birthday, Ray continues to be involved with the AAL as the Officer Commanding Moorebank Squadron and administering the Padstow Squadron, where he continues to work with the cadets.

• For further information on the Australian Air League: phone 1800 502 175 or email info@airleague.com.au.

TOP LEFT Comr Raymond Bell OAM announced as a recipient of the RSL ANZAC of the Year Awards 2022. Photo: Michael Oud.

ABOVE Ray saluting Queen Elizabeth in 1954.

ABOVE Ray as an NCO of Marrickville Company during the 1940s.

WORDS Flight Lieutenant (AAFC) Paul A Rosenzweig OAM

POWERED FLYING AT CAIRNS

THE AAFC'S AVIATION PROGRAM allows Cadets to have a safe, positive and educational aviation experience to foster an early interest in flying. One way of achieving that is through a non-instructional Cadet Aviation Experience (CAE) flight in a powered aircraft.

Cadets from two squadrons of No.1 Wing (North Queensland) had the opportunity to participate in CAE flights on the weekend of 26-27 March from Cairns Airport. The flights were provided by Townsville Flight Training, which operates from Townsville International Airport.

The Commanding Officer of No.106 Squadron (Tablelands) Flying Officer (AAFC) Sarah Lannan said: "The activity was organised as part of the ongoing efforts by the AAFC to get our cadets flying and to inspire our youth. All cadets and staff had a great time."

The intention is that every Cadet in their first year of membership, with parental consent, will have access to at least one non-instructional flight – at no cost to the Cadet or their family.

RIGHT Enjoying a CAE flight in a Cessna 172S, from left, ACW (AAFC) Romney Blunt and Cadet Sergeants Abbey and Prue Pillar from No.106 Squadron (Tablelands).

GLIDING THEORY

IN MARCH, SOUTH AUSTRALIA'S BALAKLAVA GLIDER TRAINING FLIGHT conducted a Gliding Theory Training Course at RAAF Edinburgh to prepare a new cohort of aviation trainees. Some had previously flown an instructional Pilot Experience flight, but for most the course was their first chance to progress the theoretical knowledge acquired in their home training curriculum.

The comprehensive training program covered general aircraft knowledge, from aviation terminology, units, and time and date formats through to Gliding Federation of Australia checklists, inspections and ground handling. Trainees also studied aviation theory, from aerodynamics to meteorology, and rules and procedures of flight.

The Flight Commander of Balaklava Flight, Flight Lieutenant (AAFC) Ian Wright said, "The attitude of the cadets was extremely positive, and they all took the opportunity to explore not just the gliding theory we presented but also to discuss careers in the fields of aviation and aerospace generally".

The Cadets then joined a series of

WA FLYING SCHOLARSHIP

continuation training weekends, and several joined gliding courses in the April and July school holidays, commencing the pathway to their first solo flight.

ABOVE Flying trainee LCDT Tegan Revolta at Balaklava Airfield with instructor WOFF(AAFC) Steve Shuck CSC. Photo: FLTLT(AAFC) Ian Wright.

LEFT Gliding trainees CSGT Jesse Isaac (left) and CUO Kshitij Sapdhare at Balaklava Airfield. Photo: FLTLT(AAFC) Ian Wright.

CONGRATULATIONS TO CADET WARRANT OFFICER LUKE YAXLEY who has been awarded a prestigious Western Australian Government flying scholarship.

Sergeant (AAFC) Michael Thomas, Social Media Coordinator with Headquarters No.7 Wing said, "A strong commitment to aviation studies and a flying career has resulted in Air Force Cadet Luke Yaxley becoming this year's recipient of the Minister for Education Aviation Scholarship".

Valued at $5,000, the scholarship is awarded annually to a Year 12 student studying aviation at a public high school in WA. It will give CWOFF Yaxley a boost in realising his aspiration to become a commercial airline pilot.

WA Education and Training Minister Sue Ellery said, "Luke displays strong integrity, leadership and determination, making him a deserving recipient of this scholarship".

CWOFF Yaxley is a senior member of No.703 (City of Fremantle) Squadron. He said his experience in the Air Force Cadets had developed both his leadership and his character.

"As well as helping me in my studies, the Air Force Cadets built my self-confidence and encouraged me to pass on my learnings by developing leadership abilities in the junior Cadets in my charge," he said. "Without the training and experience gained through Cadets, I would never have become the person I am today".

ABOVE CWOFF Luke Yaxley standing in front of a Cessna 172.

AUSTRALIAN AIR FORCE CADETS

The AAFC aims to better equip young people, aged 12-18 years, for community life by fostering initiatives, leadership, discipline and loyalty through training programs which are also designed to stimulate an interest in Defence. For more information and to find your nearest squadron, go to airforcecadets.gov.au.

TOP TIPS FOR TAX TIME

FOLLOW THESE TIPS TO MAXIMISE YOUR TAX REFUND (OR TO MINIMISE THE TAX YOU HAVE TO PAY) AND TO SLEEP SOUNDLY AT NIGHT, KNOWING THAT YOU'VE SATISFIED YOUR LEGAL OBLIGATIONS WITH THE AUSTRALIAN TAX OFFICE.

DO IT ON TIME

If you're completing your own tax return through the myGov portal (my.gov.au), it must be lodged by 31 October. Most of your data should be automatically pre-filled by the end of July, so all you need to do is check the details are correct, add in your legitimate deductions and submit. Make sure you include investment income (e.g. dividends and rent), gig/cash economy income and capital gains or losses (e.g. on the sale of an investment property, shares or cryptos). If you are likely to miss the deadline, a registered tax agent (RTA) should be able to lodge your return for you later than 31 October, provided you register with an RTA before that date.

READ THE ATO GUIDES

The Australian Tax Office (ATO) website contains informative guides for a range of occupations (including the ADF) that explain what income must be declared and what expenses are allowable as tax deductions. Work-related deductions could include car or travel expenses, uniform expenses, self-education expenses and even fitness costs for certain occupational categories where exceptional fitness is required.

WORKING FROM HOME

If you've worked from home during the year, particularly during the COVID-19 pandemic, you may be able to claim phone, internet and other home office expenses. The ATO website contains comprehensive information about what you can claim and how to calculate it.

KEEP RECORDS

Only make claims that you can prove with written records (e.g. receipts). While our tax system is basically an honour system, the ATO's data matching software, which includes comparing your claims to those of your peers, is pretty efficient. Taxpayers are selected at random every year for an audit and if you've made larger claims than your peers, you may be flagged for closer scrutiny. You won't necessarily be asked every year to provide evidence of your claims, but you should be prepared in case you are. Making false or undocumented claims can lead to substantial fines and regular audits of your tax affairs in following years.

GET HELP IF YOU NEED IT

If you're not confident about preparing your own tax return or you need specialist advice, consider using an RTA or a qualified accountant if your tax affairs are complex. The areas in which taxpayers make many mistakes (often to their disadvantage) include investment properties, shares and cryptocurrency trading. To establish that the person or organisation you choose is registered, or to find an RTA in your area, use the search function on the Tax Practitioners Board website (tpb.gov.au). You can search for a suitable accountant through a professional body, such as CPA Australia (cpaaustralia.com.au) or the

Chartered Accountants Australia New Zealand (charteredaccountantsanz.com).

UNDERSTAND THE FEES AND CHARGES

There are hundreds of options available when choosing an RTA or an accountant. Make sure you understand their fee structure, which should be a flat fee, not a percentage of any tax refund to which you're entitled.

BE ORGANISED

RTAs and accountants generally charge for the preparation of your tax return by reference to the time they spend on it, so being organised can save you money. If you collect receipts on random bits of paper and hand them over in the proverbial shoe box or can't provide the evidence to justify the claims you want to make, you are likely to end up paying far more in professional fees or will receive a tax refund which is lower than it should be.

WATCH OUT FOR INVESTMENT SPRUIKERS

Some RTAs and accountants may also be licensed financial advisers, mortgage brokers or real estate promoters, or they may be part of a network promoting those services. Such operators may offer to do your tax return for free or at a heavily discounted rate in return for you agreeing to do a 'financial health check' or even signing up to the purchase of investment products from which they will earn a commissions or incentive payments. Be aware of the motives of the advisers before you engage them to prepare your tax return. They may not be acting in your best interests.

IF YOU'RE LATE, DON'T WAIT

If you haven't lodged a tax return for prior years, we recommend you lodge the outstanding return(s) voluntarily, rather than getting caught out by the Tax Office. That way, penalties will generally be lower, and arrangements may be made to pay off any outstanding tax in a manageable way. In many cases, you could be due a refund, so lodging outstanding returns may even turn out to be a financially pleasant experience.

USE YOUR REFUND WISELY

If you are fortunate enough to receive a substantial tax refund, use it wisely. An unexpected windfall like that could be used to pay off high-interest debt, set up an emergency fund, or be used to start a savings plan for a larger purchase you may want to make in the future. Consider sitting on your refund for a short time while you carefully think through your options to really make the most of the opportunity.

Air Commodore Robert M C Brown AM FCA (Ret'd)

Robert is a chartered accountant, a financial educator and an independent member of the ADF Financial Services Consumer Centre (adfconsumer.gov.au).

ADAPT TO THRIVE

FORMER AIR COMMANDER AUSTRALIA, **AIR VICE-MARSHAL JOE IERVASI** EXPLAINS HIS PHILOSOPHY OF COMMAND, LEADERSHIP AND MANAGEMENT.

ABOVE Air Commander Australia Air Vice-Marshal Joe Iervasi AM, CSC addresses 2022 Air & Space Power Conference delegates at the National Convention Centre, Canberra.

THE FOLLOWING DISCUSSION encompasses my key philosophies associated with command, leadership and management within the RAAF and the Australian Defence Force. I have had the fortune to develop and shape these philosophies throughout my career via research, study, application and experience. I am thankful for the opportunity to do so.

So, why a philosophy? Life is unpredictable. If there's one thing I've learnt from history, it is that no one has been able to predict the future. Life evolves; it is shaped by, and in turn it shapes, the environment within which it exists. As Darwin identified, it is not the smartest or strongest that survives, but those that are capable of adaptation.

But we want to do more than just adapt to survive; we want to adapt to thrive. And to thrive we need an aim point, a purpose, a vision of what could be. That purpose is framed by our beliefs, values and identity.

Articulating a philosophy which is founded upon your beliefs, values and identity helps to keep you centred and remain true to yourself. It provides the basis upon which you can draw a line on what you accept, and what you don't. It provides a benchmark for decision-making and keeps you accountable for your actions. Because if you can't be true to yourself, who can you be true to?

What is the purpose of the RAAF?

Well, the purpose of the Australian Defence Force is to defend Australia and its national interests in order to advance Australia's security and prosperity – adapt to survive and thrive. The mission of the RAAF is to provide air and space power effects as part of a joint force in times of peace and war. As commanders, leaders and managers, our part is to ensure that the RAAF – as a national institution – endures to provide its continuing effect to Australia's security and prosperity. We are, therefore, stewards of the institution. Our guiding philosophy is to ensure the institution continues to evolve (adapt to survive and thrive) to remain relevant, credible and reliable.

How do we evolve? The RAAF, and the ADF, in a physical sense is a small force. We don't have resilience or redundancy through mass, so we are critically dependent upon our people and systems to deliver the greatest possible bang-for-buck – to adapt and evolve quicker than our adversaries. From a design perspective, our guiding philosophy is that quality is the central attribute that mitigates our lack of mass. Quality has two dimensions – depth and breadth. Experience has shown that development of quality depth must occur before broadening. Why? Because a depth of quality is associated with higher cognitive skills which are fundamental to supervision, leadership, command and management. Those high-order cognitive skills generate individuals, teams and organisations that can adapt to, and deal with, complex, vague and ambiguous situations. An organisation which has at its core a deep experiential and cognitive baseline is an organisation which is inherently adaptable and resilient. We want to avoid the generation of "Jacks of all trades and masters of none".

Once individual experiential depth is attained, the next step is to develop experiential breadth. This breadth is understanding of, and integration with, the broader organisation and its objectives, and underpins the character of joint operations.

COMMAND AND CONTROL

Command is the authority which a commander lawfully exercises by virtue of rank or assignment. Control is the authority exercised by a commander over part of the activities of subordinate, or other, organisations not normally under their command. Command and control is the process and means for the exercise of authority over, and lawful direction of, assigned forces. Command could be viewed simplistically to be 'easy' because

command is specifically the authority invested in a position to make decisions – you need to do this because you are ordered to do so. But authority without associated leadership and management is unlikely to create or foster an organisation where individuals strive to be their best. Command includes responsibility for health, welfare, morale and discipline. While it might be true to say that when you join the services, you are there to defend democracy, you're not necessarily in one – if the climate you create stifles initiative and independent 'flare' then the organisation is unlikely to be sustainable or adaptable. Why? My experience is that for adaptation to be sustainable, change needs to occur at the individual level. Centrally based reform programs with poor connection or relevance to the periphery (where the bulk of the organisation works) are unlikely to be successful.

So, one of my command philosophies has been, "Morale is our centre of gravity". This philosophy was developed with my executive team when I was Commanding Officer No.3 Squadron. We concluded that if we could implement an environment whereby individual and collective morale is actively fostered, then there would be no limits on what the squadron could achieve.

CREATING THE TEAM

Confidence has a large part to play in how individuals pursue their lives. Some people are blessed with an innate level of self-confidence and regardless of life's setbacks can dust themselves off and keep moving. Others are not the same. I have found that an encouraging word at the right time has made a marked difference to how I have felt and how I have responded throughout my career and life. Self-doubt can creep in no matter your age, rank or experience.

Team sports have played a large part in my life, notably soccer and cricket. I have found that the best teams I have been in are those that actively work together for a common goal, not for individual recognition or glory. Everyone within the team had a different strength, but together we were stronger. When mistakes were made, we each learnt by them and improved over time. We became brilliant at the basics; we worked as a team; and we kept the bigger picture. Taking a team approach has been another of my guiding philosophies. So how did that apply?

The first is to recognise that there are both formal and informal structures within any organisation, and notably within the RAAF. The military hierarchy and chain of command works well for order, discipline, administration, and organisation. But the heart of command, is the command team. The command team is the symbiotic relationship between the commander and the senior enlisted leader (the Warrant Officer). While there is only one decision-maker (the commander), the Warrant Officer is there for three primary reasons: to ensure commander's intent is understood and implemented; to shape and influence decisions; and to be the primary adviser for workforce – health, well-being, morale and capability. As a commander, I have been blessed to have had some outstanding Warrant Officers in each of my appointments. They have kept me honest and have had my back when things got tough. They have provided me with the confidence I have needed from time-to-time to get things done. If you have a choice, don't leave home without one!

Air Vice-Marshal Iervasi checks his equipment in the back seat of a No.77 Squadron F/A-18B at Andersen Air Force Base during Exercise Cope North 20 in Guam.

COMMAND GIFTS

I spoke with every incoming unit, wing, and group commander to outline my framework for psychological safety. I referred to that as two 'gifts'.

Gift no.1. I'm not expecting that every decision you're going to make is going to be the right decision. That's okay. Even when I know you're going to make a wrong decision, if that decision is reversible, I'm still going to let you make it. Because part of the process of learning to be a commander and a leader is the ability to recover from your own decision-making. There's nothing more powerful than a commander who can stand up before the unit and say, "That was an error. That was a decision I took that wasn't right. I recognise that. Thank you to those who advised me. I'm changing the decision."

Gift no.2. I can place a problem set on a table in front of five different commanders and they'll come up with five different answers. And that's okay, too. I'm not expecting homogeneity of decision-making. You need to make the best decision based upon your own context and what's important. So, you don't need to come up with the same answer. And if that doesn't work, refer to Gift no.1 and fix it.

Being a commander is having a courage of your convictions, following through and making decisions – even if that decision is not to make a decision. In the military we drive on decision making and implementation, but with sufficient checks and balances that we can assure the highest integrity of decisions.

There's more I can say on commander's intent and implementation, but perhaps for another article. I hope you have found these perspectives interesting. Command, leadership and management are a human endeavour, so work on being a good human in the first instance.

WARRANT OFFICER LEON JEFFERY HAWES BEM

15 September 1928 – 8 June 2022

LEON HAWES ENLISTED IN THE RAAF in 1947 and was posted to No.78 (F) Wing at RAAF Williamtown the same year. A posting to Central Flying School at RAAF East Sale followed, and then back to Williamtown, this time to No.2 Operational Training Unit (2OCU).

Leon served a tour of duty with No.1 (B) Squadron at Tengah, Singapore from 1952 to 1954 when the squadron was conducting bombing operations with Lincoln aircraft against communist terrorists in the Malayan jungle.

He returned to 2OCU at Williamtown for the conduct of Sabre trials, then between 1954 and 1969, he had a series of postings working on Mirage aircraft with No.3 Squadron at Butterworth and No.75 Squadron at Williamtown. He was a member of the Fast Caravan deployment of Mirage aircraft from Williamtown to Butterworth in May 1967. His final posting was No.76 Squadron at Williamtown in 1969.

Leon attained the Rank of WOFF and was discharged at Williamtown in 1970 after 23 years of service. Leaving the RAAF, he worked for the Commonwealth Department of Works at Williamtown in charge of maintaining the runway and airfield lighting.

On retirement, Leon worked as a volunteer at the Nelson Bay Golf Club conducting electrical maintenance and installations.

He was a well-respected airman and SNCO. He had a tenacious ability to "get things done". He was a good boss, mentor and influenced the colleagues who worked for him and with him and was a great friend to many both in and outside the Air Force.

GROUP CAPTAIN PETER JOHN OWEN HACKETT

14 January 1940 – 19 May 2022

PETER HACKETT GREW UP IN ST KILDA, MELBOURNE, before joining the RAAF in 1961 as a Cadet Aircrew on No.44 Pilots Course at No.1 Basic Flying Training School, Point Cook. He was a popular member of his course, which combined the last group of RAAF College graduates and direct entry cadets.

HRH The Duke of Edinburgh, who was in Perth to open the Commonwealth Games, reviewed Peter's graduation parade.

Selected for fighters, Peter was posted to No.2 Operational Conversion Unit (2OCU) and completed No.17 Sabre Course. A posting to No.77 Squadron at Butterworth, Malaysia followed in December 1963.

Peter flew operational missions during confrontation, including a tour at Labuan in Borneo, and completed four tours in No.79 Squadron Ubon, Thailand. In 1966, he was selected in the initial cadre of crews to be trained on the F-111. A precursor to the F-111 training was a Canberra conversion at Amberley and a tour of duty with No.2 Squadron at Phan Rang, Vietnam, in 1967. Following completion of his tour, he underwent F-111 conversion in the United States.

Delay of the F-111 project resulted in a posting to Central Flying School in 1969 to undergo instructor training on Macchi MB-326H aircraft. A posting to No.2 Flying Training School at Pearce, WA, followed where in 1971 he flew in the Macchi Pair display team with Doug Riding (who later retired as an Air Marshal) for the RAAF 50th Anniversary celebrations.

In 1971, Peter was posted back to 2OCU at Williamtown to complete a short Mirage conversion and he remained on staff until he was selected as a member of the team responsible for the gifting of Sabre aircraft to the Indonesian Air Force (TNI-AU). He subsequently served at Ishwahudi Air Base in Indonesia as the Commanding Officer of the Sabre Advisory Unit assisting the TNI.

He returned to the staff of 2OCU in 1974 before posting to the personnel staff in Canberra in 1976.

He completed RAAF Staff College in 1978 and remained on staff until he was selected as Commanding Officer No.6 Squadron flying F-111 aircraft. He assumed command of the squadron in July 1980. Peter was promoted to Group Captain in July 1983 and posted to the Australian High Commission, London as the RAAF Defence Advisor.

On return to Australia, he was appointed Director Personnel – Officers. He retired from the RAAF in 1987.

Peter served as Chairman of the Corrective Services Commission of NSW for a few years before moving to private consultancies and subsequently successfully owning and operating three businesses. He became a graduate of the Monash/Mount Eliza School of Business, and a Fellow of the Australian Institute of Company Directors.

During his service in the RAAF, Peter was awarded the Australian Active Service Medal 1945-75 with clasps 'Malaysia' 'Vietnam' 'Thailand', Vietnam Medal, General Service Medal 1962 with Clasps 'Borneo' 'Malay Peninsula', Australian Service Medal 1945-75 with Clasps 'Thailand' 'SE Asia', Republic of Vietnam Cross of Gallantry with Palm Unit Citation, and the United States of America Air Force Outstanding Unit Award with Valour Device.

FLIGHT LIEUTENANT WALLACE BOLTON RIVERS DFC AND BAR

14 June 1924 - 2 May 2022

WALLACE RIVERS GREW UP IN VAUCLUSE, Sydney and worked as a clerk before enlisting in the Australian Army as a Private with No.2 Military Districts Signals Training Battalion on 4 August, 1942. He discharged from the Army in February 1943 to join the RAAF and undergo pilot training, graduating as Airman, Pilot (Pilot 2).

During his career he qualified on Auster, Wirraway, Mustang, Vampire, Meteor and Lincoln aircraft. Wally served two tours in Korea with No.77 (Fighter) Squadron. The first, flying Mustang aircraft, from 27 June 1950 to 21 December 1950 and the second, from 30 August 1951 to 10 June 1952, flying Meteor jet fighters. He volunteered to fly additional sorties and by the time he completed his tours of duty in Korea, he had flown 319 combat missions, the second highest flown by an RAAF pilot. A truly outstanding feat.

During his second tour, Wally flew a USAF F-86 Sabre while based at Kimpo, one of only a few Australians to do so.

He was commissioned as a Pilot Officer in September 1951.

For his service in Korea, Wally was honoured with the awards of Distinguished Flying Cross (DFC) during his first tour of duty, while a Warrant Officer, and a Bar to the DFC during his second tour as a Flight Lieutenant. He was also awarded the US DFC and US Air Medal during his second tour.

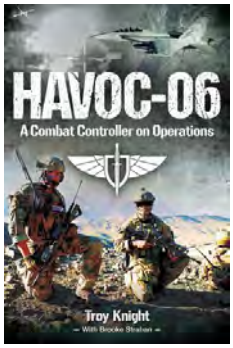
In 1953, he was a member of the RAAF contingent to visit the United Kingdom for the coronation of Her Majesty Queen Elizaetn II.

Completing 14 years of service, Wally resigned from the RAAF in 1957 and continued to fly In civilian life, spending much of his time overseas, notably in Libya and Papua New Guinea.

During his flying career, Wally was involved in several aircraft accidents. The first was flying a Mustang over Tokyo Bay when he collided with a Royal Navy Fleet Air Arm Firefly and parachuted into the bay. A second accident involved a mid-air collision with an American light bomber, and again he parachuted to safety.

At 43 years of age, Wally held a commercial helicopter pilot licence and was involved in a helicopter accident on an oil rig in Bass Strait in March 1968. The accident was not attributable to pilot error. At the time, his total flying experience was some 7,900 hours of which 3,200 hours had been gained on rotary wing aircraft, including approximately 140 hours on the Bell 204B type.

ABOVE Flight Lieutenant Wally Rivers of No.77 Squadron RAAF unfastens his parachute harness after flying a USAF F-86 Sabre jet, Kimpo, South Korea, 1952. Photo: AWM.



REVIEW BY Bob Treloar

HAVOC 06, A COMBAT CONTROLLER ON OPERATIONS

By **TROY KNIGHT,**
with **BROOKE STRAHAN**
Big Sky Publishing; RRP $26.26

HAVOC 06 is an autobiography of a former Australian Combat Controller, Troy Knight. As a RAAF Airfield Defence Guard, Troy sought more adventurous activities than defending military airfields. He found them on combat operations in several theatres around the world as a contractor supporting military combat operations and as a Combat Controller.

Combat Controllers are qualified to call in air strikes in support of troops on the ground. They are deployed with the ground forces and must be able to hold their own in combat. For the airborne role they are trained as Joint Terminal Air Controllers, but they must first pass the Commando qualification course to enable deployment with Special Forces. Troy completed tours in Afghanistan, training courses in the United States and further specialist training in Australia.

He describes in detail the adrenalin rush when he stepped from a Blackhawk helicopter onto the battlefield on his first mission in Afghanistan as a Combat Controller and the challenges of controlling air strikes onto a confused battlefield, without which the survival of the ground force would be in doubt.

He vividly captures the sense of personal danger and the challenges that confront combatants in every battle. In doing so he uses the language of a trooper which is often colourful, earthy and raw and may confront some readers. However, he has captured the essence of personal involvement in combat as a Combat Controller.

Havoc 06 is a very readable book and will provide strong interest, and possibly education, for a reader of military matters and recent Australian commitment to combat operations.

REVIEW BY Bob Treloar

BATTLE OF THE ATLANTIC: RAAF in Coastal Command 1939 - 45

By **JOHN QUAIFE**
Big Sky Publishing: RRP $19.99

FROM THE OUTSET OF WORLD WAR II, Germany pursued a strategy to isolate Britain from the support available from its allies. A relentless U-boat campaign nearly succeeded, resulting in a long and difficult battle for control of the Atlantic Ocean fought on the Allied side by Coastal Command and the Royal Navy.

In *Battle of the Atlantic,* a co-operative production with RAAF'S History and Heritage Branch, John Quaife provides an excellent account of Australian participation in the campaign while expertly placing it within the context of the overall battle situation.

In 1939, No.10 Squadron RAAF took delivery of its Sunderland aircraft and were later joined by No.461 Squadron RAAF, also flying Sunderland aircraft, in Coastal Command.

The author provides a very human perspective of the men who flew the Atlantic and Bay of Biscay missions, their backgrounds, operational exploits, successes and losses. He takes the reader into the aircraft cockpits, describing the actions of crew members in their defensive battles with attacking aircraft, and pursuing defiant U-boats.

More than 400 Australians lost their lives, with more than 100 others wounded. Returning to Australia at the end of the war those veterans were given little recognition, and many were openly criticised for not fighting the Japanese.

The *Battle of the Atlantic* is well written and easy to read. The author provides an excellent overview of the Battle of the Atlantic including the excitement and terror of individual combat actions, not all of which were successful. It will capture reader's attention and provide a much overdue reminder of the importance of an often-overlooked campaign and it will appeal to a wide readership.

REVIEW BY Michael Nelmes

UNITS OF THE ROYAL AUSTRALIAN AIR FORCE

By **DESPINA TRAMOUNDANIS**
Big Sky Publishing: RRP $49.99

FOR THE RAAF CENTENARY, RAAF History and Heritage produced the first comprehensive volume of RAAF unit histories since the 75th Anniversary 10-volume box set *Units of the Royal Australian Air Force: A Concise History.* The single-volume work is somewhat smaller in scope as it covers only the 120 or so units and organisations still extant in today's Air Force. Totalling 620 pages, it forms the second volume of a box set of two in a slip case together with *Aircraft of the Royal Australian Air Force,* which was published last year.

The attractive, glossy volume is arranged in six parts: headquarters and force element groups, wings, branches and directorates, numbered units (squadrons, schools, etc), named units and bases. The units, squadrons and schools are grouped all together in numerical order irrespective of type, a departure from the format of the original set which grouped them under separate headings by type.

Each unit narrative is headed by its badge, motto and any battle honours. Appendices include colours, battle honours, unit citations and maps. While the original set listed base movements and commanding officers under each unit entry, in the new volume those details form part of the narrative. The comprehensive, 35-page index is a useful aid to researchers.

The narratives are well-written in large font. Each includes a present-day colour photo – no historic images.

Added to the three-volume *The Royal Australian Air Force History* and the Aircraft volume, it will be a highly desirable addition to the library of anyone interested in the illustrious history of our Air Force.


ASTRA AEROLAB
Newcastle Airport
Every aspect of Astra Aerolab is designed to uplift performance.
With outstanding integration of technology and lifestyle in an idyllic region, co-located with RAAF Base Williamtown and Newcastle Airport, this is a unique opportunity to join the world's leading defence, aerospace and innovation precinct.
Leasing opportunities now available.
Contact: Marcus Polites
+61 478 677 263
mpolites@newcastleairport.com.au
Newcastle Airport,
RAAF Base Williamtown,
NSW, Australia
astraaerolab.com.au
UPLIFTING OPPORTUNITY

Powering up
from the beginning

We are immensely proud to have powered the Royal Australian Air Force throughout its illustrious history. Our long relationship remains strong to this day, and we will continue to support the air men and women into the future. We have shared a century of innovation, partnering to break new ground in the field of aviation, and we are committed to continuing that pioneering spirit to enable future generations to reach for the skies.