WINGS

AUTUMN 2020
VOLUME 72 NO.1

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ON THE COVER

Air Affairs Australia Pty Ltd Phoenix HP Drone set for launch at the Jervis Bay Range Facility. Photo by Rob Power

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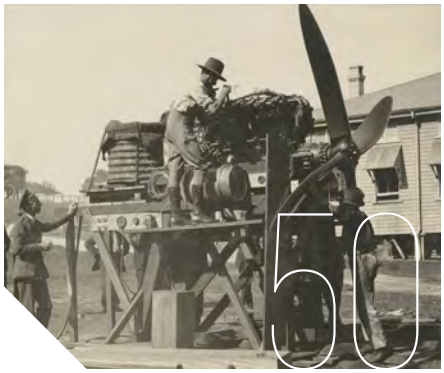

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FROM COMMANDER FLEET AIR ARM

AS COMMANDER OF the Fleet Air Arm, it is a privilege for me to be able to contribute to Wings. Noting the publication in March, it would be customary in the past to speak of the return to work after the Christmas New Year period and outline our challenges and outlook for the busy year ahead. The summer of 2019/2020 has, however, been somewhat different.

Elements (not just aviation) from across all of Defence, supported by our industry partners, were called into action to assist the Australian community in the bushfire emergency. Unprecedented numbers of people, equipment and resources have been brought to bear across multiple states. Since mid-November, the Fleet Air Arm (FAA) has been heavily committed. From a Fleet Air Arm perspective, MRH90, MH-60R and EC 135 helicopters have been provided by both day and night to support the awe-inspiring efforts of the RFS, CFA and State Emergency Service. Aircraft were used to map fire fronts, move equipment and emergency services personnel, carry out search and rescue (SAR) operations, evacuate residents under threat of the fire front and to conduct medical evacuations for those injured in the fires. Notably, the FAA has also been involved in providing additional SAR support in the recent flood emergency.

At the time of writing this article the FAA has supported Operation Bushfire Assist by flying more than 635 hours. A large proportion of those hours were flown in December in challenging and hazardous conditions. Flying was exceptionally demanding, visibility very poor, and at times required flight on Night Vision Devices during the day. The missions the crews flew and successes they achieved were amazing and required tenacity, astute judgment and leadership to achieve safely. This was the case for all aviation crews across the three services.

What has been most pleasing has been the commitment and desire to assist our communities by Defence and contracted personnel. Even though the initial recall of personnel occurred during the middle of the Christmas holidays, personnel willingly and overwhelmingly committed to assist where possible. The professionalism, resilience and courage of our people helping our fellow Australians highlights the extraordinary men and women we have in Defence. While it was a privilege to contribute to the collective national effort by supporting our fire and emergency services, the efforts, resilience and determination of the state authorities and firefighters alongside the emergency services personnel have been truly inspirational.

As our support requirements slowly diminish with Operation Bushfire Assist, the Fleet Air Arm will continue to focus upon providing lethal maritime aviation capabilities at sea through the provision of rotary-wing support within the broader Maritime Task Groups. We have a busy year ahead delivering what Government requires use to do. Growth of our workforce is being enabled by a range of innovative approaches to the way we develop and train our people.

Undoubtedly it has been a busy start to the year for the ADF.

Commodore Don Dezentje
Commander Fleet Air Arm
Royal Australian Navy

Royal Australian Navy Fleet Air Arm aircraft on standby at RAAF Base Williamtown as part of the firefighting efforts in NSW. Photo by ABIS Leo Baumgartner.

A VERY WARM New Year's welcome to all our readers and contributors; we look forward to providing another year of interesting and entertaining *Wings* editions.

As for quite a few other Australian institutions, 2020 marks a very significant milestone for the Air Force Association (AFA, formerly Royal Australian Air Force Association). Founded as the Australian Flying Corps Association and later as the Australian Flying Corps and the RAAF Association, it has been in continuous operation for a century.

During that time, our service men and women have been involved in myriad operations: global warfare, warlike conflicts, humanitarian, natural disasters and peacekeeping. Recently we witnessed the historic first callout of the Reserves and the deployment of Defence personnel to provide a range of support services during the catastrophic bushfires that ravaged eastern states.

The Association's first concern has always been the welfare of serving and former serving members with a focus on Air Force veterans. Last year, AFA responded to the recommendations of the Productivity Commission inquiry into compensation and rehabilitation for veterans and Robert Cornall's Scoping Study into veterans' advocacy. Cornall's report was largely supported. The Productivity Commission's Report contained some concerning proposals, although several of its recommendations were supported. I have amplified those concerns, together with a summary of the major actions currently being pursued by AFA in the Association section of this edition (see page 69).

I would like to take the opportunity now, to thank our business and industry partners who continue to support the ADF and its Veterans. Without that support, Wings would not be possible and by all accounts the magazine is making a valuable contribution to the positive perception of the ADF and the RAAF, in particular. I commend the magazine to you and trust your support is rewarded.

Carl Schiller, OAM CSM
National President

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Membership is open to serving and former members of the Australian Defence Force and Allied Armed Forces, their family members, current and former Air Force Cadets, Air League Cadets and members of the public who have an interest in aviation and who support the mission and objectives of the Air Force Association.

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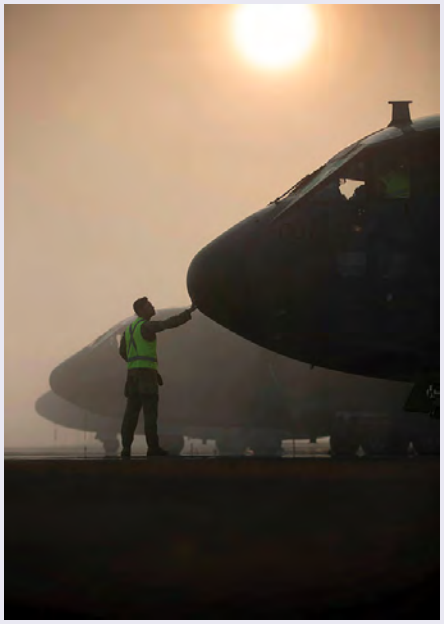
ABOVE Members of 16th Regiment Emergency Support Force take a break during Operation Bushfire Assist to feed 12 young koalas at the Cleland Wildlife Park at Mt Lofty, SA. The koalas were moved from Kangaroo Island as part of the SA Government's new Wildlife and Habitat Recovery Task Force to establish a disease-free insurance population.



ABOVE RAAF Sergeant Glen McCarthy in front of an Australian Army C-20J Spartan at RAAF Base East Sale, in support of Operation Bushfire Assist 19-20.

NO.10 SQUADRON MEMORIES

YOUR CENTREFOLD OF Neptune SP2H A89 -273 brought back some great memories of this aircraft. As a young Sgt Signaller from 1962 to early 1967 I flew some 26 sorties in this particular aircraft (A89 - 273) as a member of No.10 Squadron which included sorties both in Australia and overseas.

This was prior to air-conditioning in aircraft and, with many racks of electronic equipment venting into the inside of the aircraft, operating in the tropics, at time at low levels with high temperatures and humidity, conditions were uncomfortable (to say the least) for the crew.

Never-the-less the strong team spirit and camaraderie leaves me with great memories.

***J R Taylor**, WgCdr Ret*

LIFE AT RAF METHWOLD, 1944

IN THE *WINGS* Winter 2019 Edition there was an article and photo about Adelaide Cadet Cpl Sean Fry Australian Air Force Cadets (605 Squadron, Seaford) whose late grandfather, Mark Fry, served in RAF 149 Squadron Bomber Command in WWII.

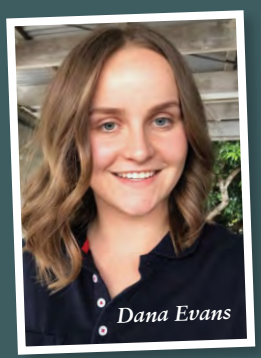
I am now 96 and also flew in 149 Squadron at the same time as Mark Fry. I even have a copy of the Battle Order for a huge Lancaster Bomber raid on Duisburg the night of 14 October 1944 listing both our names, me as the Wireless Operator in a crew and Mark as a mid- upper Gunner in another crew.

It sounds to me that Sean may be interested in being in touch to learn a bit more about life at RAF Methwold in 1944.

Congratulations to all involved in the new Wings magazine. I love it.

***Tony Adams**, Sydney, NSW*

*Please send letters to **editor@raafapublications.org.au**, including your name and details. Letters may be edited for length and clarity.*



FLYING HIGH

ATTENDING AN AIR Force Flight Camp for young women at the RAAF Base Pearce, WA set a Queensland college graduate on her way to a Defence career.

St Mary's College Ipswich graduate Dana Evans has begun a four year Aeronautical Engineering course at the Australian Defence Force Academy (ADFA). After being sworn into the Defence Force in late January, she travelled to Canberra to complete a six-week basic training course.

"This course will provide me with a greater range of opportunities than I would have been able to undertake if I was following a general university pathway," Dana said. "It will also provide me with new experiences, like living on campus at the University of New South Wales and partaking in a variation of the military life, allowing me to grow as a person and enabling me to get more involved in the ADFA/NSW University way of life."

Dana began to explore the possibility of a career in the Defence Force in her final years at St Mary's College Ipswich. "St Mary's offers a wide range of opportunities outside of the standard school regime which initially allowed me to attend a Flight Camp for women at the RAAF base in Perth."

At the end of her time with ADFA, Dana is looking forward to pursuing career opportunities with the Defence Force. "The course will open up potential for numerous engineering roles in the RAAF. I am particularly interested in working with the design and manufacture of aircraft safety equipment."

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EDITED BY Bob Treloar

A UNIFIED FORCE

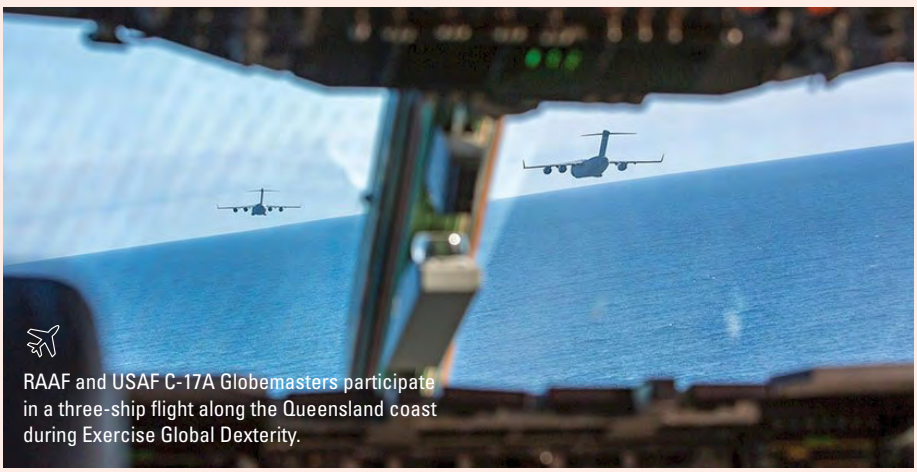
ROYAL AUSTRALIAN AIR FORCE (RAAF) and United States Air Force (USAF) C-17 Globemaster aircraft participated in a joint strategic airlift training exercise off the coast of Queensland in November 2019 to develop interoperability procedures and skills.

Exercise Global Dexterity delivered a major milestone for the RAAF and USAF air mobility fleets as maintenance and technical crews combined in teams to operate the assigned assets from each nation as a unified force element. No.36 Squadron at RAAF Base Amberley hosted the exercise.

After participating in "five-ship" air-to-air refuelling training with RAAF KC-10A Multi-Role Tanker Transport aircraft, and airdrop formations, a formation of three C-17s descended to low level (100m) for transit along the Queensland coast back to Amberley.

Speaking of the growing interoperability and partnership between the RAAF and USAF, Colonel Geoff Lohmiller, Vice Commander of the USAF 15th Operations Group, said Australia and the US are the left and right hand of the Pacific Ocean. "There are unique complexities to face and learn from when working in a mixed team. This training and tactical-level integration of C-17 aircrew is how we remain effective and responsive into the future."

Source: Defence Connect



RAAF and USAF C-17A Globemasters participate in a three-ship flight along the Queensland coast during Exercise Global Dexterity.

ABOVE Personnel from Air Task Group 630 and Joint Task Force 633 at the ADF's main operating base in the Middle East. Photo by LCDR Alistar Tomlinson.

Middle East MILESTONE

AIR FORCE RECOGNISED the scope of commitment to the Middle East as five RAAF aircraft types were on concurrent operational deployment to the region. They included the C-130J Hercules, KC-30A multi-role tanker, P-8A Poseidon, E-7A Wedgetail and the C-17A Globemaster III. Together those aircraft have provided diverse air capability including mobility, intelligence, surveillance, supply and transport.

While most of the aircraft have been active in the Middle East for many years, the P-8A was deployed for the first time last October to support the International Maritime Security Construct (IMSC) over the Strait of Hormuz.

The Air force has been working in the Middle East for more than 15 years and more than 300 Air Force personnel are currently supporting several operations in the region.

Source: RAAF News

Delivering THE GOODS

FRESH FOOD, SCIENTIFIC EQUIPMENT, medical supplies and machinery were flown to the Antarctica in November on the first cargo flight of the summer season.

A RAAF C-17A Globemaster III carried almost 18,000kg of cargo from Hobart to Australia's Casey research station. After flying 3,500km south the aircraft landed on the 3.5km glacial runway at Wilkins Aerodrome.

Source: Department of Defence

LEFT C-17A at Wilkins Aerodrome, Antarctica.

Training mission COMPLETED

AFTER ACHIEVING ALL TRAINING MILESTONES planned for transition to the F-35A Lightning II at Luke Air Force Base (AFB), Arizona, US, the RAAF began returning its F-35A Lightning II pilots, maintainers and aircraft to Australia last December.

The RAAF began training at Luke AFB with the 61st Fighter Squadron and Aircraft Maintenance Unit in December 2014 with two F-35s. Since then, 34 Australian pilots and 16 instructor pilots have qualified.

Luke AFB is the RAAF's F-35A delivery point, and Australian pilots will return several times a year to ferry the country's new fifth generation fighters to Australia. Ferry missions will continue until the RAAF receives its last F-35A in 2023.

The RAAF and US Air Force (USAF) approach fighter flying and pilot training from different cultural perspectives. Working alongside each other has seen the USAF challenge some of the RAAF's ideas and vice versa. The relationship has helped both forces examine their modes of training and operation.

Seven F-35As arrived at RAAF Williamtown in December, bringing the total number based in the country to 13, with another five at Luke AFB. By the end of 2020, the RAAF expects to own 33 F-35As and procurement of the next 24 has been approved.

The RAAF has a stated requirement of 100 new fifth-generation fighter aircraft, to replace the ageing F/A-18A/B Hornet fleet.

Sources: USAF Air Education and Training Command; The Diploma

LEFT RAAF pilots following their final training flight at Luke Air Force Base.

Final flight in the CLASSIC HORNET

PILOTS FROM THE RAAF'S No.2 Operational Conversion Unit (2OCU) have conducted their final flight in the Classic F/A-18 A/B Hornet as the Unit transitions to the F-35A Joint Strike Fighter.

Commanding Officer 2OCU, Wing Commander Scott Woodland, said 2OCU's final Classic Hornet mission is a fitting tribute to this significant milestone in Air Force history. "2OCU's critical role in preparing generations of Classic Hornet fighter aircrew with the skills and competency to engage in fighter combat has laid the very foundations of RAAF Air Power capability since the introduction of the platform in 1985," he said.

The future of fast-jet aircrew training at 2OCU is now focused on supporting fifth-generation capabilities, with the arrival and operational sustainment of the F-35A Lightning II.

In a fitting tribute, 2OCU was awarded the Kittyhawk Trophy as the Most Efficient Fighter Squadron in 2019. The trophy sponsored by the Fighter Squadrons Branch (formerly the Kittyhawk Association) of the Air Force Association was presented to WGCDR Woodland by GPCAPT John Haly DSC, CSC (OC 81 Wing) in the presence of Unit personnel at a hangar ceremony on 11 December 2019.

Source: Defence Connect

ABOVE F/A-18 Hornets with their replacement F-35 Lightning II aircraft.

LEFT FSGT Jason Blackburn and FLGOFF Aimee Parsons proudly hold the Trophy in front of a Kittyhawk aircraft.

Pilatus PC-21 TRAINER FLEET

THE FINAL AIRCRAFT in the RAAF's Pilatus PC-21 pilot training aircraft fleet arrived at RAAF Base East Sale, Victoria in December. The Australian Department of Defence acquired 49 Pilatus PC-21 turboprop trainer aircraft as part of the AIR5428 project to replace RAAF's PC-9/A and CT-4B training aircraft.

The PC-21 has a range of 1,300km and can reach an altitude of 7,500m. Powered by Pratt and Whitney PT6A-68B turboprop, the aircraft can attain a maximum speed of 685km/h. It will equip undergraduate pilots with the basic skills needed to undergo training on the F-35A, MRH-90 and other advanced military aircraft. From early 2020, the PC-21 will also be used to support flight test work at the Aircraft Research and Development Unit (ARDU), RAAF Base Edinburgh and as a Forward Air Control (FAC) platform at 4SQN, RAAF Base Williamtown.

Source: Air Fore Technology

New indigenous STRATEGIES

RAAF'S NEW ABORIGINAL and Torres Strait Islander strategy and action plan, launched by Chief of Air Force Air Marshal Mel Hupfeld, focuses on improving retention and career development opportunities for Defence Aboriginal and Torres Strait Islander personnel.

AIRMSHL Hupfeld said increasing Aboriginal and Torres Strait Islander contribution within Air Force is critical to developing its workforce and enhancing Defence's overall capability through inclusion. The Air Force goal is to reach an Indigenous participation rate of five percent by 2025.

Source: Defence Connect

A RARE SIGHT

ALL EIGHT OF No.36 Squadron's C-17A Globemasters came together on the tarmac at RAAF Base Amberley for the first time last November.

Although the fleet has been operating with eight aircraft for four years, the nature of the C-17A mission frequently disperses No.36 Squadron personnel and aircraft around the world and prevents all eight aircraft assembling at home base.

Amberley is the largest RAAF operational air base. Along with No. 36 Squadron, the Base hosts: No.1 Squadron (F/A-18F Super Hornet); No.6 Squadron (EA-18G Growler); No.33 Squadron (KC-30A Multi-Role Tanker Transport); No.35 Squadron (C27J Spartan); and CHC Helicopters Search and Rescue.

Source: The Aviationist

ABOVE Eight C-17A Globemaster aircraft from No.36 Squadron on the flight-line at RAAF Base Amberley.

An Air Force C-130J Hercules provides transport to the SA fire-fighting deployment.

ADF Bush fire CRISIS SUPPORT

THE AUSTRALIAN DEFENCE FORCE (ADF) commenced Operation Bushfire Assist 19-20 and raised Joint Task Forces in NSW and Victoria to provide Navy, Army and RAAF support to assist the bushfire battle in South East Australia.

The RAAF dedicated five aircraft including C-27J Spartan, C-130J Hercules and C-17A Globemaster to support civilian agencies in Victoria, NSW and SA and provide logistic and ground support, health, specialist capabilities and accommodation from several bases.

Those wide-ranging support activities included the provision of:

- Air traffic controllers to provide flight information services at the Bairnsdale Airport.
- C-27J Spartan to evacuate personnel from Mallacoota and to deliver fuel and supplies to towns isolated by the fires.
- Aerial surveillance of infrastructure and roads in the fire-affected areas by maritime surveillance aircraft from RAAF Base Edinburgh.
- Airbase access and support for Large Aerial Tanker and spotter aircraft at RAAF Base Richmond. A Striker Vehicle and crew were made available from Richmond to support NSW Rural Fire Service helicopter 'hot-refuelling' at Picton Showgrounds.
- Army and Air Force engineering teams to provide on ground support in the Snowy Mountains and Riverina area.
- A Role One Medical Facility at RAAF Base East Sale.

Source: Department of Defence

ABOVE C-27J Spartan pilots from No.35 Squadron, work in arduous conditions as they assist evacuees during the bushfires in Mallacoota, Victoria.

First KC-30A MRTT ELEPHANT WALK

THE RAAF'S NO.33 SQUADRON recently performed an 'elephant walk' with five of its seven KC-30A Multi-Role Tanker Transport (MRTT) aircraft taxiing in line for departure from RAAF Base Amberley. The line up stretched over 500m along the taxiway.

No.86 Wing Commanding Officer group captain Steve Pesce said: "Launching five KC-30A aircraft demonstrates a capacity to concurrently transport over 1,000 passengers or ferry more than 40 Hornets across Australia."

Alternatively, five aircraft could position 1,800km from base and offload 250 tonnes of fuel to airborne receivers over four hours.

The capacity to project this magnitude of air power at range has previously been beyond Air Force's capability.

Four of the aircraft left for separate missions after the walk, including air-to-air refuelling training, airlift, and developmental flight test activity. RAAF received the first KC-30A in 2011 and the seventh in 2019.

Source: Air Force Technology

EDITED BY John Kindler

Counter-drone tech DEMONSTRATION

LOCKHEED MARTIN has successfully demonstrated a directed energy, laser weapon for the US Air Force (USAF). The Advanced Test High Energy Asset (ATHENA) was developed to integrate seamlessly and provide a cost-effective, complementary anti-drone capability within the network of systems the war-fighter is already using.

During the demonstration, ATHENA was operated by USAF personnel in a fully networked engagement environment with a government-furnished Command and control (C2) system and a remote radar sensor.

Cues from C2 using the supplied radar track were applied to slew, acquire, track and defeat the target drone with a high-energy laser. ATHENA was able to destroy multiple drones in engagements representative of those encountered by US armed forces today.

The system is transportable and therefore enables the Air Force to emplace it anywhere they need to defend infrastructure, force elements and high-value assets.

Source: Defence Connect

RUSSIA SHOWS HYPERSONIC MISSILE SYSTEM

RUSSIA HAS SHOWN US observers its hypersonic missile system to uphold requirements of the New Strategic Arms Reduction Treaty (New START), according to the Ministry of Defence of the Russian Federation.

The Avangard missile system, slated to enter combat service in December, features a hypersonic glide body that, according to Russian state media, is capable at travelling in excess of 20 times the speed of sound. Observers were shown the weapon over the course of two days under the terms of the 2011 New START treaty which governs the size of Russian and US nuclear arsenals.

Russian officials previously described the missile as 'invulnerable' to missile defence systems with Russian President Vladimir Putin saying that in tests the missile successfully manoeuvred "horizontally and vertically at hypersonic speeds".

Putin said in an earlier statement: "The weapon is capable of performing sharp manoeuvres on its way to targets making it absolutely invulnerable for any missile defence system."

Hypersonic missiles pose a threat to traditional missile defence systems as the weapons' speed makes them difficult to intercept.

The US Congress has mandated an operational hypersonic weapon by 2022, and the UK has set aside funds for the development of hypersonic systems.

Source: Airforce Technology

RAF Reaper UAV.

Team Reaper to deliver remotely PILOTED AIRCRAFT SYSTEM

THE AUSTRALIAN DEPARTMENT of Defence has down-selected General Atomics' MQ-9B Sky Guardian for its armed Medium Altitude Long Endurance (MALE) remotely piloted aircraft system (RPAS) under Project Air 7003.

Defence Minister Linda Reynolds said: "Cutting-edge technology of this kind, with advanced sensors and systems, would complement advanced aircraft such as the F-35 Joint Strike Fighter and ensure that the Australian Defence Force maintains state-of-the-art capability."

The team assembled by General Atomics to deliver the RPAS for the Australian Defence Force is known as Team Reaper Australia. It includes Cobham Aviation Services Australia, Flight Data Systems, Collins Aerospace, Raytheon Australia, Airspeed, CAE Australia, Sentient Vision Systems, Ultra Electronics Australia, Quickstep Technologies and TAE Aerospace.

Defence Industry Minister Melissa Price said: "Local companies that provide a range of innovative sensor, communication, manufacturing and lifecycle support services will have the opportunity to showcase their capabilities throughout this development process. Australian defence industries are world-class and are extremely well-placed to be involved in projects like this."

Source: Airforce Technology

Seeking partners for JBMS project

NORTHROP GRUMMAN is inviting partners to collaborate on the development of a fifth-generation multi-domain joint battle management system (JBMS) for the RAAF under Project AIR6500.

The proposed JBMS multi-domain solution will allow for coordination of joint weapons employment, air battle management and ground-based air defence in operational theatres, according to Northrop Grumman. It will provide the RAAF with the capability to link disparate platforms, systems and sensors across multiple domains. The solution is expected to provide shared situational awareness and enable the RAAF to quickly plan a response to threats on the battlefield.

Northrop Grumman Australia chief executive Chris Deeble said: "Northrop Grumman aims to lead industry support to the RAAF as it fields a survivable, scalable and modern, next-generation JBMS under AIR6500. We're committed to a sovereign capability that's designed and developed through close collaboration with other Australian industry members. We recognise that a program of this size, scope and complexity will demand the most innovative, best-of-breed capabilities and a prime systems integrator partnering with Australian industry who can deliver world-class resources to the Australian Defence Force."

Source: Airforce Technology

Remote air control TOWER SHOWCASED

KONGSBERG DEFENCE AUSTRALIA, with the support of Indra Australia, is showcasing its Remote Towers solution at RAAF Amberley. The Remote Towers solution streams images from advanced electro-optical sensors across a low bandwidth connection to provide the same out-of-the-window view quality as sitting in an air traffic control tower at the airfield. Live infrared image is also proving to be an effective situational awareness asset at night, particularly in monitoring wildlife movements.

The solution is controlled from the Remote Tower Module (RTM) located about 1,200km away at Kongsberg Defence Australia's Canberra office.

Representatives from the ADF, Airservices Australia, and the Civil Aviation Safety Authority attended live system demonstrations in Canberra, conducted under the sponsorship of the RAAF Air Warfare Centre Innovation Hub.

The ability to implement stable real-time remote operations across a commercial point-to-point connection provides significant opportunities for a country like Australia.

This technology will reduce operating and infrastructure costs and will open up opportunities for remote locations and communities all over the country.

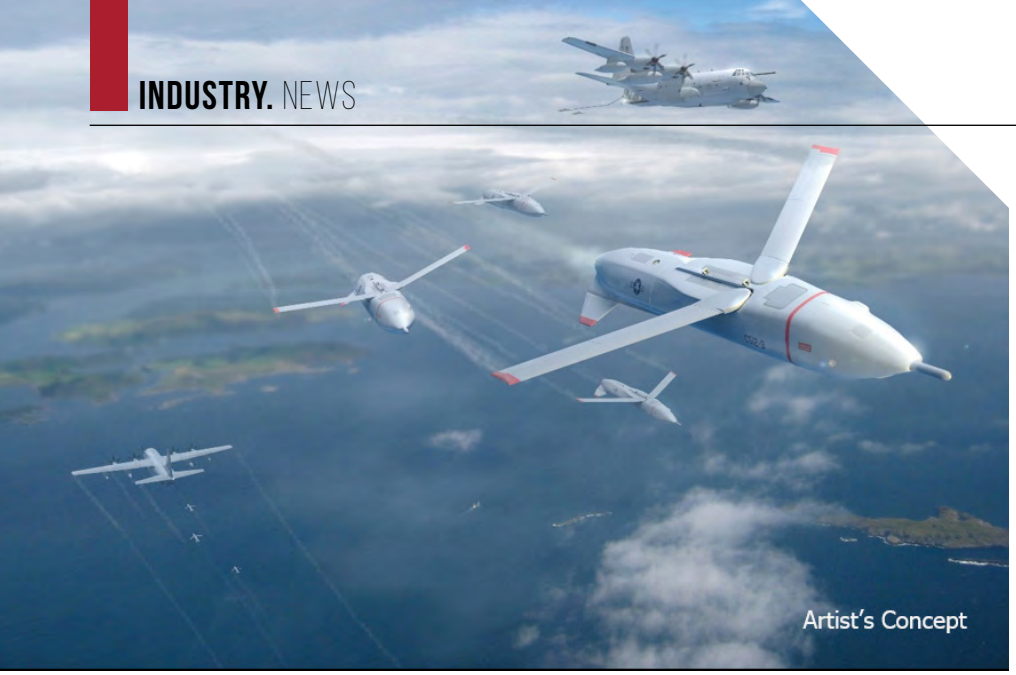
RADAR SENSING CONCEPT FOR TEMPEST FIGHTER

LEONARDO UK has demonstrated the capabilities of new radar receiver/warner technology in a laboratory demonstration for the UK and other partners in Team Tempest. Team Tempest is a group of industry partners, including BAE Systems, Leonardo, Rolls-Royce and MBDA, working with the UK Ministry of Defence on the sixth-generation fighter.

Leonardo, leading the effort to develop radar warning technology for the aircraft, noted that the size of the new sensor is about a tenth of a standard radar warning receiver. The technology demonstrated four times the accuracy provided by the sensors that are currently in use.

Source: Airforce Technology

ABOVE
A mock-up of the Tempest next-generation fighter aircraft at DSEI 2019, ExCel, London. Photo courtesy Swadim.



RAF to launch swarming DRONE SQUADRON

THE ROYAL AIR FORCE is set to reform 216 Squadron on 1 April 2020 to bring swarming drones into service and assess their capabilities.

Development of the project has so far been under the control of the RAF Rapid Capabilities Office, which supports the Tempest fighter project. However, the RAF has so far been tight-lipped about the size and scope of the plans.

Announcing the project in February last year Britain's then Defence Secretary Gavin Williamson said: "I have decided to use the Transformation Fund to develop swarm squadrons of network-enabled drones capable of confusing and overwhelming enemy air defences. We expect to see these ready to be deployed by the end of this year."

The Ministry of Defence had previously indicated the drones would work alongside fighter aircraft like the F-35 and Eurofighter Typhoon to increase their lethality. "By working with our F35 and Typhoon combat aircraft, these swarms will allow our pilots to deliver precise, lethal combat power more effectively and safely."

AUSTRALIA & BOEING SIGN C2 SYSTEM CONTRACT

THE AUSTRALIAN DEPARTMENT of Defence (DoD) has awarded a $170m contract to Boeing Defence Australia to continue the integrated air battle management system installed at RAAF Bases Edinburgh and Williamtown.

Known as Vigilare, the technology is a sophisticated command-and-control (C2) system that combines data from a range of sources, including tactical data links, sensors and intelligence networks, to support the C2 functions and provide a comprehensive view of battlespace in the air and joint domains.

The DoD has renamed the system Wakulda, which means together, and expects it to be operated for 10 more years. The network-centric command and control system passed operational testing in Australia in April 2011 and was accorded final operational capability status in March 2013.

Source: Airforce Technology

RUAG completes first component repairs on F/A-18 Super Hornet

RUAG INTERNATIONAL has finished the first component repairs on the RAAF's F/A-18F Super Hornet multi-role fighter aircraft.

Successful completion marks the first use of Australia's current in-country capabilities. In addition, hydraulic component repairs on main landing gear (MLG) brake assemblies and hydraulic swivel joints were conducted by RUAG's Hydraulic Centre of Excellence at Bayswater, Victoria and at RAAF Base Amberley.

RUAG MRO International senior vice-president aviation international Stephan Jezler said: "The unique capabilities at the RUAG Australia Hydraulic Centre of Excellence prove a significant contribution and ensure our solutions continue to meet the demands of the RAAF and their aircraft well into the future.

The extensive work on the Hydraulic, APU and Undercarriage Systems of a variety of RAAF platforms, including the F/A-18 A/B Hornet, C-130 Hercules, E-7A Wedgetail, C-27J Spartan, AP-3C Orion and the C-17A Globemaster III has made RUAG MRO teams indispensable.

Source: Airforce Technology

BELOW RAAF F/A-18F Super Hornet multi-role fighter aircraft. Photo © RUAG Group.

Skyborg concept.

SKYBORG: THE US AIR FORCE'S FUTURE AI FLEET

THE US AIR FORCE is flying at supersonic speeds towards an Artificial Intelligence (AI) enabled fleet. Under project Skyborg's direction, future fighter jets won't be supported by a wingman, but by an unmanned combat aerial vehicle. Finger four has been the dominant fighter aircraft formation since the 1930s. The world's most advanced air combat fighter, the Lockheed Martin F-35, costs about $100m per platform. Four of those in formation commits to almost half a billion dollars' risk.

The USAF project Skyborg aims to address that risk by replacing some of those expensive manned assets with more affordable Unmanned Combat Aerial Vehicles (UCAVs) acting as wingmen. USAF has reserved about $54 million in 2020 science-and-technology and experimentation funds for the Skyborg initiative.

Dynetics' X-61A GAV performs maiden flight

DEFENCE CONTRACTOR DYNETICS has performed the first flight test of its X-61A Gremlins Air Vehicle (GAV) in Utah, USA.

The X-61A GAV is being developed under the US Defense Advanced Research Projects Agency's (DARPA) Gremlins program. The goal is to enhance the US Armed Forces' operational flexibility by providing them with the capability to launch and recover a large number of low-cost, reusable Unmanned Aerial Systems (UAS).

The test marks the program's development of phase 3 demonstration objectives. The flight was conducted at Dugway Proving Ground near Salt Lake City and involved the use of a C-130A aircraft operated by TBM/Butler.

It lasted for one hour and 41 minutes and saw the GAV demonstrate one captive-carry mission on board C-130A, airborne launch and free flight.

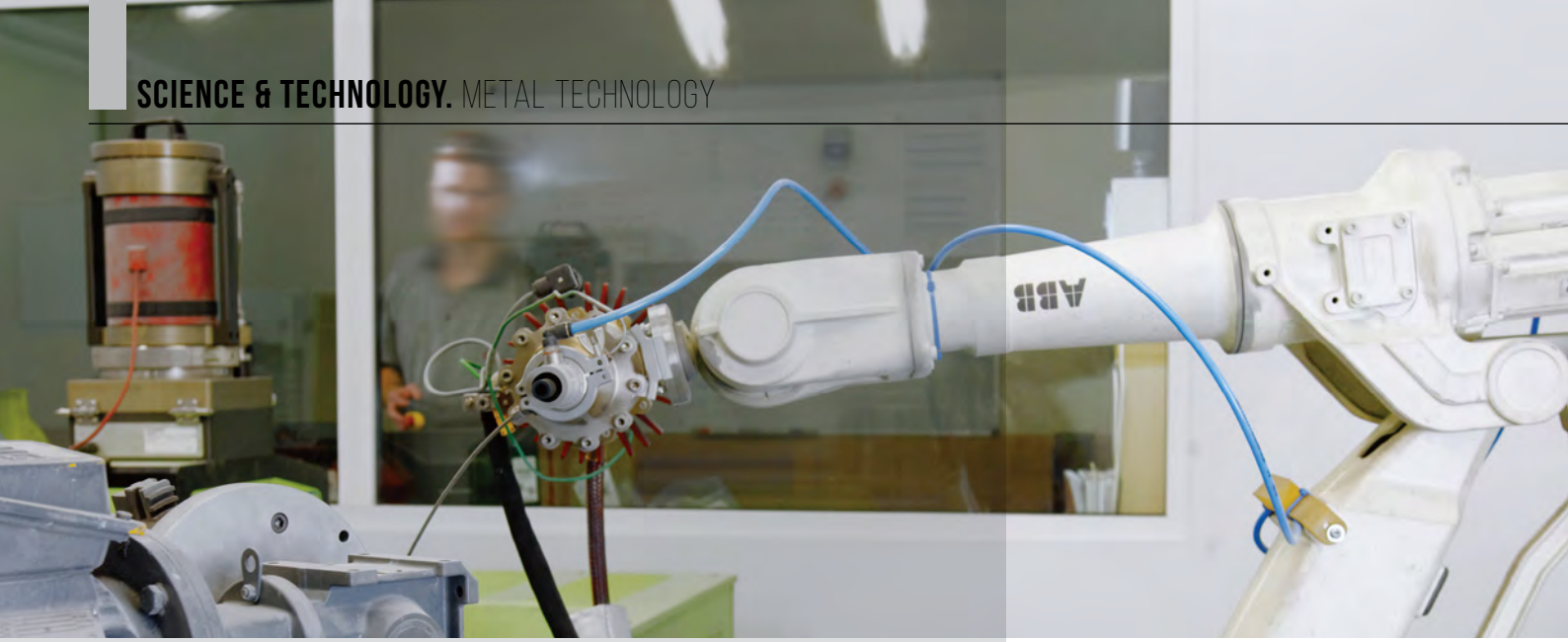
The objectives of the test were to demonstrate the successful launch of GAV from a C-130, and rate capture, wing deployment, cold engine start, as well as stable and powered flight.

Additionally, air and ground-based command and control systems were evaluated, which also included communication through a data link. The verification of flight termination and parachute recovery of the GAV and the deployment of GAV docking arm formed part of the trials.

X-61A flew as expected, achieving all test objectives. The operational system of the flight was rendered successful. However, the vehicle was lost during recovery due to failure of main chute deployment.

Source: Airforce Technology

Dynetics' X-61A GAV performs maiden flight.



THE 3RD INDUSTRIAL REVOLUTION

ADDITIVE METAL TECHNOLOGIES OFFER A NUMBER OF EXCITING APPLICATIONS AND COST-EFFECTIVE OUTCOMES FOR AEROSPACE SUSTAINMENT.

ADDITIVE MANUFACTURE IS INCREASINGLY being referred to as the third industrial revolution, in that complex three-dimensional shapes can be built layer by layer through material deposition.

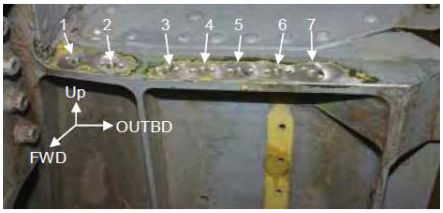
While significant attention is being directed towards creating new shapes, there is a genuine need to restore worn/damaged components to their original condition and design integrity. Additive technologies provide a number of exciting and cost-benefit outcomes, particularly in corrosion protection and the restoration of corroded/damaged metallic components.

Aircraft maintenance is an ongoing process and involves both the repair of legacy aircraft and the development of capability for next-generation aircraft. Maintenance procedures for legacy aircraft identify components and structure that no longer meet specification or are considered unfit for purpose and are typically replaced or undergo extensive repair. In many instances, failure to meet specification is due to the loss of metal from the component or structure (see right).

Material loss can occur through corrosion, wear, erosion or impact. Replaced components or repaired structures can have a significant price tag and adversely affect aircraft availability and as such contribute significantly to the cost of ownership.

Computer-aided design tools and computer-aided manufacturing processes using highly sophisticated machines ensure the next-generation of aircraft (such as the F35 Joint Strike Fighter) possess components and structure that have little or no excess material. Hence, the challenge to develop additive metal technology (AMT) applications for current and next-generation aircraft so components and/or structure can be returned to operational service in a safe, timely and cost-effective manner.

RUAG Australia has been providing innovative repair and reengineering solutions to the Australian Defence forces for many years. The focus has been to recover metal components and has been undertaken in close collaboration with the Australian Defence



ABOVE Seahawk corroded internal/external frame and intermediate gearbox foot.

TOP RUAG Supersonic Particle Deposition Tool.

Material/AMT application matrix.

Application Material	Corrosion Protection	Wear Resistant	Substrate Geometry Restoration	Structural Restoration	Structural Enhancement
Magnesium Alloy	SPD	SPD,	SPD	SPD	SPD
2024 Al Alloy	SPD, (LAD)	SPD, (LAD),	SPD, (LAD)	SPD, (LAD)	SPD, (LAD)
7075 Al Alloy	SPD, (LAD)	SPD, (LAD)	SPD, (LAD)	SPD,LAD	SPD,LAD
High Strength steels >260ksi	SPD, (LAD)	LAD, (SPD)	LAD, (SPD)	LAD	LAD
Stainless Steels	SPD, LAD	LAD, (SPD)	LAD, (SPD)	LAD, (SPD)	LAD, (SPD)
Titanium Alloys	SPD, LAD	SPD, LAD	LAD, (SPD)	LAD ,(SPD)	LAD, (SPD)
Inconel Alloys	N/R	SPD, LAD	LAD	LAD (SPD)	LAD, (SPD)

Photo courtesy RUAG

research establishment, Defence Science and Technology Organisation (DSTO), academia and the Australian Defence airworthiness authority.

Utilising that background knowledge, a material/AMT application matrix was developed and within that matrix Supersonic Particle Deposition (SPD) and Laser Additive Deposition (LAD) were identified as potential effective AMT technologies (see matrix above).

SPD, also referred to as cold spray, is a technology in which metal powder particles are accelerated to supersonic speeds in a high-pressure expanded gas flow, and impact a solid surface with sufficient energy to cause plastic deformation and bonding with the underlying material. Bonding is a result of high-strain rate deformation and adiabatic shear instabilities at the bond interface.

The application of SPD as opposed to other powder deposition technologies offers the following demonstrable benefits: no heat affected zone; no interface oxides; generation of surface compressive stresses; and no thickness limitations.

In addition, SPD is a controllable additive manufacturing technology and can be used to repair high tolerance dimensional characteristics, close fitting surfaces, and critical moulding features such as the F/A-18 main landing gear hydraulic swivel joint' (right).

LAD, also known as laser cladding (LC), uses a laser beam to form a melt pool on a metallic substrate, into which powder/wire is fed. The powder/wire forms a deposit that is fusion bonded to the substrate.

The required geometry is built up layer by layer. LAD overcomes some of the limitations of SPD, such as line-of-sight orientation of the worked component which primarily limits the treatment to external surface applications.

LAD provides the following benefits: general benefits of powder deposition; high bond strength, particularly on hard substrates; very high-quality finish – hard, dense with a low level of dilution and the surface finish can be smooth; localised heat input; very rapid solidification; very fine wear resistant microstructures; and minimal line of sight limitation.

AMT APPLICATIONS

RUAG Australia has led a 10-year program of research and development of SPD technology, and its technical efforts and outcomes have been instrumental to economic sustainment of the Australian Defence Force's aerospace capability.

Australia's first SPD application for a component repair was conducted on a Royal Australian Navy Seahawk helicopter main transmission in November 2009. That transmission module is still in service and has accrued in excess of 1,300 flight hours without any degradation of the deposition or any adverse effect on the substrate.

Since that initial deposition, in excess of 40 other components for both rotary and fixed-wing aircraft have been successfully recovered using SPD technology. Recent applications have even recreated net shaped features on damaged components. Accrued flight hours for the current applications are in excess of 7,700. Cost savings to the Navy as a result of the implementation of SPD repair solutions on their Seahawk fleet (16 helicopters) has been calculated at $6 million over five years.

While SPD is typically viewed as a repair technology, the technique can also be used to prevent damage. In developing repairs for the Seahawk transmission housing, which is manufactured from magnesium alloy, the selected repair SPD material was aluminum alloy 6061. That material not only provided geometry restoration but also enhanced corrosion protective properties. Such is the success of SPD treatment, the RAN has approved its application on all mating surfaces as a preventative solution. Additionally, experimentation has shown that SPD can be used to deposit an extremely thin coating of material across corrosion-prone joints or over rivet fasteners, thus sealing joints and fasteners and preventing moisture ingress and corrosion initiation. In that regard, SPD can be more effective at eliminating environmental exposure than wet assembly.

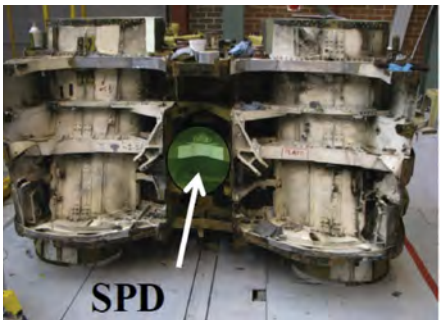
In a similar manner to the development and implementation of SPD repairs, LAD repairs for geometry restoration have commenced. The first LAD repair, certified in 2012, involved the restoration of a stainless-steel flight control bracket (left). While the replacement costs were considered to be low, the lead time to obtain a replacement component was considered unacceptable and LAD treatment was adopted as an efficient alternative. RUAG Australia is currently working on a number of

additional LAD repair solutions for the recovery of titanium, high-strength steel and aluminium components.

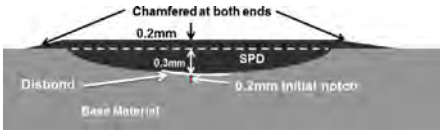
THE NEXT STEPS

After successfully demonstrating the benefit of AMT for geometry restoration and observing the ability of AMT depositions to carry load; considerable research, experimentation and analytical modelling has been undertaken to assess the potential of SPD as a technology for structural restoration. Outcomes of the experimentation and analysis has demonstrated that:

- SPD treatment can clearly carry load, is durable and performs well in dynamic load conditions. Experimental data established that the durability of SPD applications have similar mechanical properties to that of the original material and can be used in a significant range of load envelopes without the need to assess specific applications. In addition, experimental data revealed that, even if the application is subject to a peak load environment greater than the recognised durability properties of the SPD, the treatment withstands the load spectra without damage for more than the design life of the component. That finding was verified by subjecting an F/A-18 centre barrel crotch treatment with SPD doublers to the RAAF operational F/A-18 load spectrum of up to 250 MPa (below left).
- SPD can be used on lap joints to effectively seal the joint and significantly retard, and possibly even eliminate the onset of corrosion and subsequent damage. As observed in the 1988 Aloha Airlines incident and more recently in similar 2011 and 2012 incidents, catastrophic failure can occur as a result of multisite corrosion damage in neighboring locations and around fastener heads (see two images bottom left).
- SPD can replace conventional patch/strap repairs (see image bottom right) and negate the structural issues associated with introducing new holes in components and the need to parasitically stiffen (i.e. locally over stiffen) the structure. SPD treatment is significantly faster and can be implemented with minimal disassembly, seals the component so that the environment can't reach any existing damage and thereby stops further corrosion. Additionally, SPD treatment can avoid the introduction of dissimilar material issues.
- SPD can be used to repair corrosion damage and the resultant embedded repaired structure has a dramatically increased fatigue life (see diagram right). Baseline specimens (blended but not SPD treated) and SPD repaired specimens were subject to constant amplitude testing to compare the effectiveness of each repair technique and to validate analytical modelling. Numerous operational load spectra were then used to assess the fatigue properties of both repair techniques; analysis showed SPD treatment increased the fatigue life of the specimen by factors of seven to 1,200 times.
- SPD has the potential to reduce the crack growth rate of a hole containing intergranular corrosion to the level of a hole without intergranular cracks (see graph above right).
- SPD treatment of stress corrosion cracking (SCC) has the potential to restore the load carrying capacity of the structure, for frame elements such as rib stiffened wing planks, to its design standard by eliminating the dramatic effect unconstrained SCC has on buckling integrity (see above right).

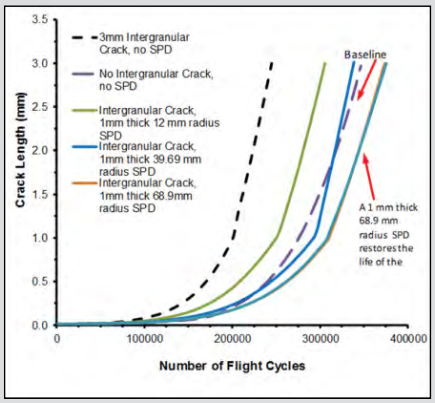


ABOVE SPD application to F/A-18 Undercarriage Crank Assembly.



ABOVE Cross-section of the embedded SPD repair.

ABOVE FROM LEFT, 1988 Aloha Airlines incident, 2011; 737 incident; SPD application over simulated fuselage lap joint.



Based on the experimentation and analysis conducted to date it is conceivable that SPD could also be used to lower the stresses associated with fatigue critical components and thereby increase both the safe life of the structure and the critical crack size, stiffen regions which are vibration sensitive or subject to severe acoustic excitation, eliminate crack growth in fatigue critical locations and extend inspection intervals. However, much more experimentation and analysis is required to fully exploit those attributes of the technology.

CONCLUSION

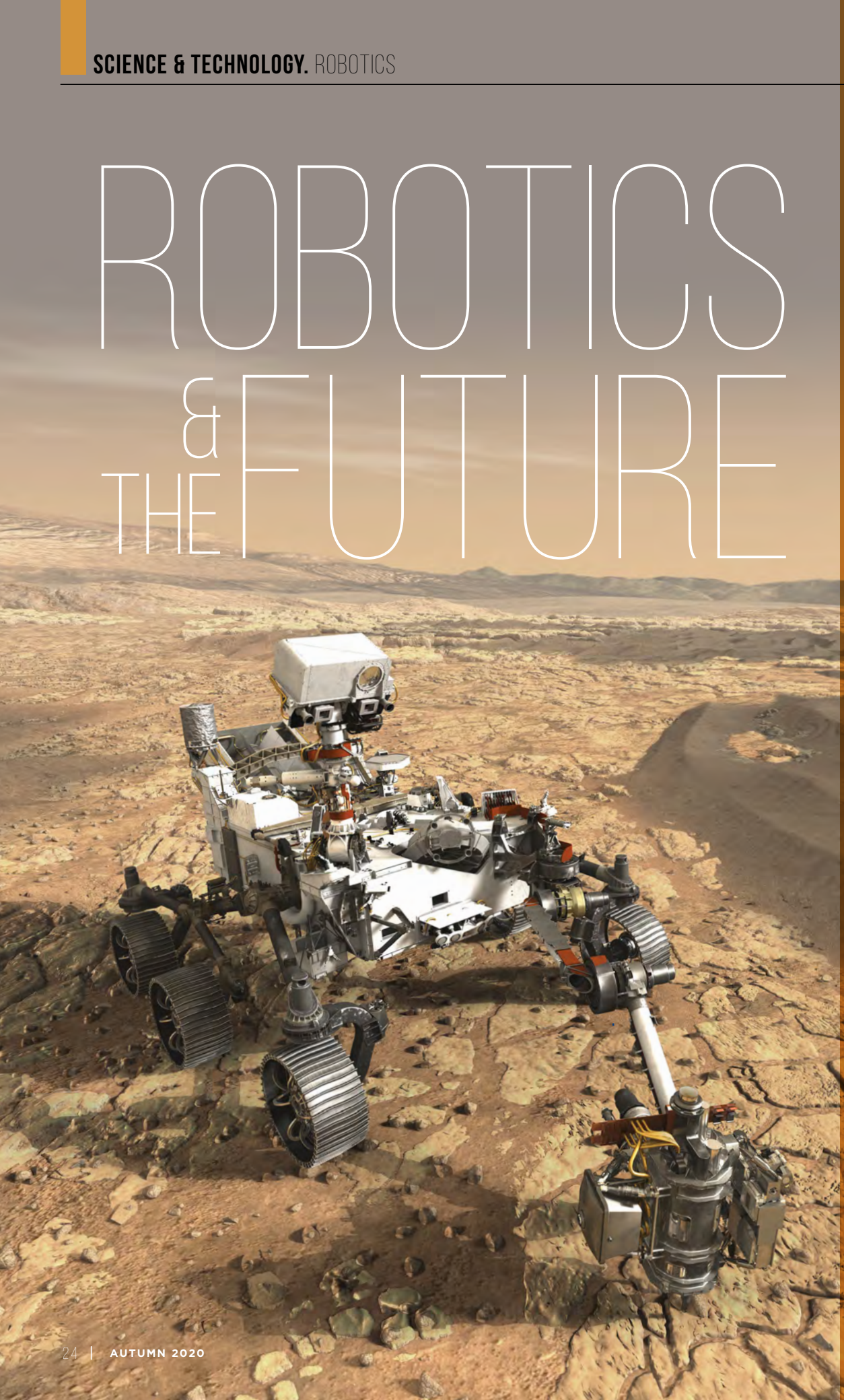
From the work undertaken and industry acceptance of both SPD and LC repairs on aircraft components it is clear that direct metal deposition technologies have the potential to restore damaged metal substrates in a safe, timely and cost-effective manner.

The current program is focused on delivering a predictive and certifiable deposition technology based on real world experience.

As already highlighted the program is underpinned by a cohesive industry, research and academia working relationship and as such further demonstrable and approved application on actual aerospace components are planned.

• This article has been is based on the technical paper "Additive Metal Technologies" presented by Neil Matthews at the 10th HVOF Colloquium (Proceedings of the 10th HVOF Colloquium, Erding, Germany 29-30 October 2015, pp 213-222).

ROBOTICS & THE FUTURE



ABOVE RIGHT Members of the NASA Mars helicopter team attach a thermal film to the exterior of the flight model of the Mars Helicopter. Photo courtesy NASA/JPL-Caltech.

LEFT Artist's concept of NASA's Mars 2020 rover exploring Mars.

FROM MANUFACTURING TO SPACE EXPLORATION, ROBOTICS ARE BECOMING INTEGRAL TO OUR DEVELOPMENT.

THE COMMON QUESTION ASKED OF CHILDREN, "What do you want to be when you leave school?" has been replaced with, "What problem do you wish to solve?". In identifying and then focusing on solving problems, we are only limited by our imagination – and the ability to maximise the technology we have at our fingertips. One such tool is robotics.

Robotics is a branch of engineering that involves the conception, design, manufacture and operation of robots; devices that operate autonomously or under pre-programmed control. The robotics field merges many technical disciplines such as: electronics, computer science, artificial intelligence, mechatronics, nanotechnology and bioengineering.

The concept of creating machines that can operate autonomously dates back to classical times, but research

MARS 2020

An example of the far-reaching effects of robotics, the Mars 2020 rover is due to launch in July this year and land on Mars in February 2021. The launch, aboard an Atlas V-541 rocket, will take place from Cape Canaveral Air Force Station in Florida, US, and is timed to coincide with the closest approach of Mars to Earth, minimising fuel requirements.

The Mars 2020 rover mission is part of NASA's Mars Exploration Program, a long-term effort of robotic exploration of the red planet. The mission will not only seek signs of habitable conditions on Mars in the ancient past, but also signs of past microbial life.

Once the rover lands on Mars, a small drone helicopter will be deployed to scout for interesting targets for study and help plan the best driving route for future Mars rovers.

Mars 2020 will use powerful instruments to investigate rocks on Mars down to microscopic variations in texture and composition. It will also acquire and store samples of promising rocks and soil, and set them aside on the surface of Mars. A future mission could potentially return those samples to Earth.

The mission will also provide opportunities to gather knowledge and demonstrate technologies that address the challenges of future human expeditions to Mars.

• For more information about the mission, see mars.nasa.gov/mars2020.

An engineer works on attaching NASA's Mars helicopter to the belly of the Mars 2020 rover. Photo courtesy NASA/JPL-Caltech.

into the functionality and potential uses of robots did not grow substantially until the 20th century. Throughout history, it has been frequently assumed that robots will one day be able to mimic human behaviour and manage tasks in a human-like fashion.

An internet search will quickly illustrate the rapid progression of robotics – from the robotic maid Rosie in the 1960s cartoon *The Jetsons* and the robot in *Lost in Space* ("Danger Will Robinson!") to the Boston Dynamics robot that performs a gymnastic routine.

As technological evolves, robots are emerging to serve various practical purposes, whether domestically, commercially or militarily.

Many robots are built to do hazardous jobs, such as searching for survivors in unstable ruins, or exploring mines and shipwrecks. Robotics is also used in STEM (science, technology, engineering and mathematics) as tools for teaching computer coding, electronics, engineering and the integration of many scientific fields.

Airborne and underwater robots are also freely available. Airborne robots are often referred to as drones, more formally known as unmanned aerial vehicles or unmanned aerial systems.

Essentially, a drone is a flying robot that can be remotely controlled or flies autonomously through software-controlled flight plans in embedded flight management systems, working in conjunction with onboard sensors and GPS. The term drone is now commonly applied to any unmanned vehicle regardless of the operating environment; land, sea, air or space.

Drones are also a massive part of the modern-day robotics industry, they have evolved well beyond their military origin to become very powerful business tools. They have also made a leap into the consumer market, and now they're being put to work in commercial and civil government applications from farming to firefighting. They are used in agriculture as crop dusters to spray pesticides and repellents and to monitor large tracks of land and animal movement.

Drones replace helicopters, at a much lower cost, to shoot cinematic photography for a wide variety of visual applications from entertainment to civic planning and advertising.

Robotics and coding subjects are being incorporated in Australian curriculums as well as extracurricular activities. The aim of those opportunities is to train interested students to design, build and code their own robots, exploring strategic application of robots in the community. Those opportunities give students the chance to create and interact in a way that is challenging and exciting; they learn to work in teams to solve real-world problems using their new robotics skills. The idea is to bring students that have a genuine interest together and educate them into the skills required for Australia's future space workforce.

Educational robotics is a broad term that refers to a collection of activities, programs, physical platforms and educational resources.

There are many robotics programs offered in Australian schools and in after-school and holiday programs. Some are skills based and others are part of a global competition. Each program has been designed to develop certain skills and to cater for varying ability. There are programs from pre-school to university, all easy to access from the internet.

Coco Dobbie & Nicola Baker, One Giant Leap (OGL) student ambassadors, and Bob Carpenter OGL mentor.

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ScanEagle is launched from the flight deck of HMAS Newcastle in the Middle East region.

DRONES

NAVY

THE ROYAL AUSTRALIAN NAVY IS EMBRACING THE CHALLENGES OF INTRODUCING A MARITIME TACTICAL UNMANNED AIRCRAFT CAPABILITY.

OVER THE PAST DECADE, modern militaries have embraced the strategic and tactical advantages offered by unmanned platforms, which are typically used for intelligence, surveillance and reconnaissance (ISR). The Royal Australian Navy (RAN) is no exception and is currently embracing the challenges associated with the introduction of a Maritime Tactical Unmanned Aerial System (MTUAS) capability.

Although a relative latecomer to modern UAS, the RAN has a long history with operating unmanned systems as target drones. From 1950 to 1998 it operated the unmanned, jet-propelled Jindivik target plane, which was controlled by pilots meeting medical standards for Air Traffic Control, and utilised a crew of five or seven personnel while airborne. Jindiviks were based at Jervis Bay Range Facility (JBRF) and used for live missile and gunnery practice, predominantly for the ship-based Seacat and Tartar missile systems, and also as a target for Sidewinder air-to-air missiles carried by the RAN's A4 Skyhawk jet fighter-bombers. Additionally, the Jindivik could be fitted with various counter-measure systems and could effectively simulate an enemy missile or aircraft attack against ships.

In the early 1960s work commenced on a replacement for the Jindivik, called the Turana. From 1971-1979, the RAN operated the Turana target, which was developed from the Ikara anti-submarine missile system. It was intended to provide a parachute recoverable pilotless target for use in gunnery and missile defence training. Trials were conducted by HMAS Swan (III) in 1978, however the project failed and was cancelled in 1979, and Jindivik remained in service until 1998.

Kalkara was originally planned to enter service to replace Jindivik in the late 1980s, however, delays in development saw its first flight at JBRF in June 1998, with operational flights commencing in February 1999. Capable of operation between 100 and 40,000ft with a top speed of Mach 0.86 and a 6-G manoeuvre limit, Kalkara could simulate missile and aircraft profiles to challenge ship and fighter aircraft weapon systems and their operators. It was phased out of service in 2008, with no replacement.

In 2013, the Fleet Air Arm (FAA) identified that the emerging technologies and capabilities associated with tactical UAS would form part of the future force mix. Although the RAN had a long history of operating unmanned systems, it had not done so for five years, and it was acknowledged that operating land-based high-performance jet-powered targets was vastly different to the expected future operation of small tactical systems from sea. Consequently, a small Unit of five personnel was established within HQ FAA, to be known as the Navy UAS Development Unit (NUASDU). NUASDU was charged with seeking to understand the evolving technology and its potential application in the maritime environment, particularly embarked in RAN ships.

In 2015, NUASDU had grown to approximately 14 personnel, was re-named NUASU and had acquired the ScanEagle system to support its aims. In 2016, NUASU conducted First of Class Flight Trials (FOCFT) with HMA Ships Choules and Newcastle, to investigate challenges associated with integrating a UAS into a seagoing platform, and to explore Ship/UAS operating limitations.

In 2017, NUASU introduced the Schiebel S-100 system to complement ScanEagle. The Unit grew to 23 personnel and conducted a deployment to Operation MANITOU with the ScanEagle system in HMAS Newcastle. Chief of Navy granted approval to commission a Squadron and the Unit continued with activities ashore and afloat in 2018, including embarked FOCFT with the S-100 system and participation in Exercise Kakadu with ScanEagle in HMAS Newcastle.

822X SQUADRON

822X Squadron was commissioned at HMAS Albatross on 25 October 2018, with Commander Michael Rainey, RAN as the inaugural Commanding Officer. This is the first time the number 822 has been used to identify a RAN Squadron, and is the first Unmanned Squadron for the FAA. As an '8' series Squadron, 822X is an operational, seagoing Squadron, and the 'X' signifies its experimental nature, to be retained until a permanent capability is fielded.

822X Squadron's mission is to conduct experimentation and evaluation activities with contemporary UAS and advanced payloads to develop operational knowledge and experience, develop orders and procedures supporting safe UAS operations, and to assess UAS capability options that support integrated warfare outcomes for the future Fleet. Specifically, the Squadron is experimenting with a range of systems to inform Project SEA129-5, which will introduce a MTUAS to the Fleet.

The Squadron has two roles: to conduct Operational Evaluation (OPEVAL) activities to inform the MTUAS project and to prepare themselves, the FAA and the Fleet for the introduction of the MTUAS capability. Fulfilling the Squadron roles involves a determination of truth from fiction, testing and trying existing theories, concepts and assumptions, and working within existing systems and processes

BELOW InSitu ScanEagle catapult launch.

ABOVE InSitu ScanEagle Skyhook recovery.

BELOW 822X Squadron Commissioning Ceremony, 25 October 2018.

to develop new procedures. While UAS have no crew in the flying platform, UAS need well-trained professionals to operate the capability safely and effectively. 822X Squadron currently consists of 32 Navy positions plus 2 full-time OEM Field Service Representatives.

THE SYSTEMS

822X Squadron operates two main systems: one fixed wing (ScanEagle) and one rotary wing (S-100), as representative examples of each type of platform. Both systems enable Navy to investigate concepts of operations and inform future capability, particularly how MTUAS will improve the situational awareness for ships, providing a significant war-fighting advantage. The two systems will permit Navy to understand the advantages and disadvantages of each type, and therefore which type (or mix) will best suit its future needs.

The InSitu ScanEagle is a Tier 2 fixed-wing, catapult-launched UAS that uses interchangeable optical surveillance payloads with image pixel comparison to find targets combined with a passive visual detection and ranging (ViDAR) search system. The ScanEagle is approximately 1.2m long, has a wingspan of 3.11m and a maximum take-off weight (MTOW) of 22kg. It has an endurance of 12 to 24 hours with a cruise speed of 55 knots and a dash speed of 75 knots. It can accommodate a payload of approximately 6.5kg. As a fixed-wing system, it requires launch and recovery equipment (LRE) comprising a pneumatic catapult launcher and a Skyhook recovery system, with a combined weight of about 2,500kg.

The Schiebel Camcopter S-100 UAS is a representative Tier 2 rotary wing UAS, capable of accommodating a range of payloads. It is 3.11m long, has a rotor diameter of 3.4m and a MTOW of 199kg. It has an endurance of over 6 hours with a cruise speed of 55 knots and a dash speed of 90 knots. The S-100's payload capacity is significantly larger than ScanEagle at 50kg, and as a Vertical Take-off and Landing system, does not require any additional LRE.

In comparing the two UAS types, the strengths of the fixed-wing system are that it is significantly quieter than a rotary system and therefore able to operate more covertly. It also has significantly increased endurance and vastly improved efficiency over a rotary wing system. A rotary-wing system, on the other hand, is noisy, larger and has significantly lower endurance. However, the fixed-wing system requires a large LRE footprint (which is a significant factor within the limited confines of a seagoing ship), and is limited in its payload capacity. The rotary system has a much reduced physical footprint due to its lack of LRE, and has a large payload capacity with multiple payload bays. The challenge is to determine which of those factors is the most important for Navy and UAS application in the maritime environment.

TOP 822X SQN and 20 STA Personnel with ScanEagle aircraft and equipment at Exercise Talisman Sabre 2019.

MTUAS OPERATIONS

822X Squadron currently operates from designated locations within the Jervis Bay area and from Navy ships. In addition to the traditional UAS role of providing persistent ISR using various payload types, the Squadron is investigating a diverse range of applications for a tactical level UAS. In surface warfare, that includes determining how the system can contribute to the Find, Fix, Track, Engage and Assess phases of the kill chain. For amphibious warfare, this might include pre-assault reconnaissance, ship to shore force protection or Special Forces support. A MTUAS may also provide pre-fire reconnaissance, observation of fire and battle damage assessment for Naval Surface Fire Support, or stand-off observation of target vessels (particularly blind-side surveillance) for maritime interdiction operations. The system may also offer capabilities such as voice or datalink relay, and provide options for force protection during sea lane transit, or have utility in humanitarian/disaster relief, search and rescue and range clearance operations.

In addition to the capabilities it may provide, a number of other considerations will determine the effectiveness of a MTUAS in the Navy context. For example, it should be capable of blue water, littoral and over-land operations, and able to conduct those operations either

embarked in ships or from bases ashore. The system may be used to complement embarked helicopters or as a standalone capability. Ideally, it would have a small overall footprint in terms of equipment and personnel for embarked installations, and the equipment needs to be rapidly deployable by road, sea, rail or strategic air.

So far, 822X Squadron's work has seen them conduct OPEVAL activities deployed to Christmas Island with both systems (ScanEagle in 2017, S-100 in 2019), a deployment with ScanEagle to the Middle East Region in 2017, participation in Exercise KAKADU with ScanEagle embarked in Newcastle in 2018, and a sea deployment with S-100 embarked in MV Sycamore in 2018. Most recently, in July 2019, almost all of 822X Squadron personnel participated in Exercise Talisman Sabre. The S-100 crews were based ashore at the Shoalwater Bay Training Area as an augmentation to Army's 20 Surveillance and Target Acquisition Regiment (20 STA), while the ScanEagle crews operated alongside the 20 STA Regiment as an 822X Squadron detachment. Information from both systems was provided to higher Headquarters, and the Navy crews earned a reputation as thorough and professional operators, who not only contributed significantly to the effort, but gained important experience, knowledge and skills for application in the RAN and the maritime environment.

THE PROJECT – SEA 129-5

The 2016 Defence Integrated Investment Program stated: "To improve the situational awareness of ships on operations, we will acquire a new tactical unmanned intelligence, surveillance and reconnaissance aircraft system that will complement other sensors and systems by extending the area able to be held under surveillance. Those systems will be progressively introduced over the decade to FY 2025-26. They will be able to operate from a range of vessels of varying size, including the future frigates and patrol vessels."

In response to that strategic guidance, Project SEA129-5 will deliver a MTUAS capability for the RAN. The project is currently in the Risk Mitigation and Requirement Setting Phase of the Capability Life Cycle. Key risk areas include having operationally viable systems at sea, physical and systems integration, payload effects and workforce generation. Based on the knowledge gained thus far, Navy believes more than one MTUAS type is required to meet Navy's needs across Offshore Patrol Vessel (OPV) and Major Fleet Unit (MFU) employment profiles.

SEA129-5 is currently expected to acquire enough systems to support 12 operational Flights, six for OPV and six for MFUs, including the new Hunter Class Guided Missile Frigate.

THE FUTURE

Navy's employment of UAS has been, and will continue to be, guided by two key documents. CN's Vision for Unmanned Systems states that "the value of unmanned systems lies in providing beyond visual horizon ISR" and that the systems will "compliment rather than replace manned platforms". In addition, the RAN MTUAS roadmap is designed to prepare Navy for MTUAS operations at sea and de-risk SEA129-5. It outlines a four-step, phased approach, which commenced in 2012 with initial Land and Sea trials conducted by NUASDU to build knowledge and training in UAS operations. It concludes with the introduction of an enduring solution in Phase 4 via Project SEA 129-5 from 2023, in the Offshore Patrol Vessel (to be delivered by Project SEA1180), and to Navy's Major Fleet Units.

822X Squadron currently consists of 32 positions, however, this is expected to grow steadily over the coming decade to a maximum of approximately 200 people, to provide and support the 12 embarked flights as part of Project SEA129-5.

Despite significant history and experience in operating unmanned systems, the FAA continues to address and seeks to understand the challenges associated with the introduction of MTUAS into the RAN, and in particular embarked operations in a maritime environment and Naval context. The early formation of NUASDU and its subsequent growth to 822X SQN has enabled a greater understanding of the capability of contemporary systems, but more importantly has exposed many of the 'unknowns' associated with those new capabilities, and the considerations that must be taken into account. This has led to Navy being a much more informed customer, at the appropriate stage of the capability life cycle, and has enabled those considerations to be factored into the project requirements, rather than discovery after acquisition.

LEFT Schiebel Camcopter S-100 UAS.

MAKING WAVES IN HYPERSONIC RESEARCH

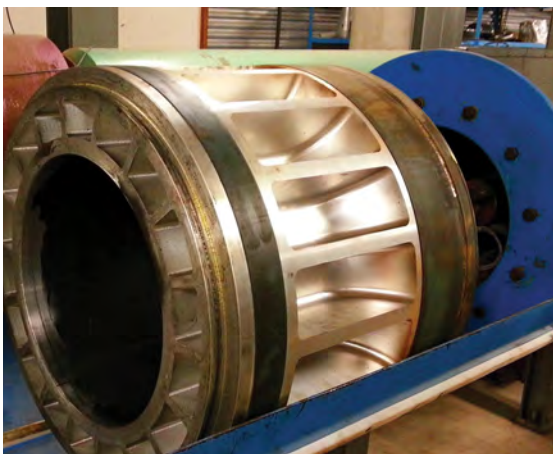
RESEARCH INTO TERRESTRIAL HYPERSONIC FLIGHT TAKES A STEP FORWARD WITH A NEW SHOCK TUNNEL AT THE UNIVERSITY OF QUEENSLAND.

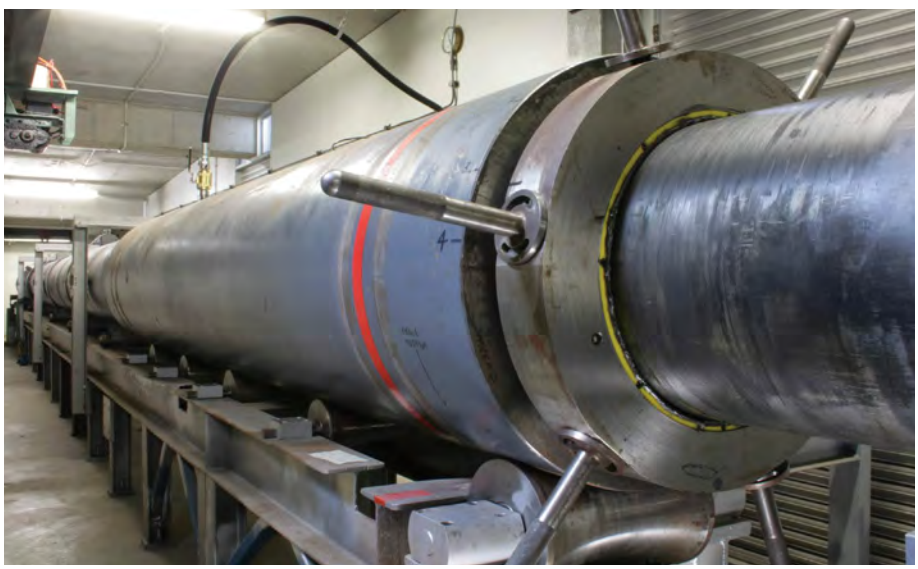
AN UPGRADE OF ONE of the largest expansion tube wind tunnels in the world will allow University of Queensland (UQ) researchers to test larger scale vehicles at up to seven times the speed of sound. Centre for Hypersonics (hypersonics.mechmining.uq.edu.au) researcher Dr David Gildfind (researchers.uq.edu.au/researcher/1978) says UQ's large expansion tube facility X3, developed by Professor Richard Morgan (researchers.uq.edu.au/researcher/256), can now be reconfigured into a reflected shock tunnel with test time duration in excess of 10 milliseconds.

"That might not sound like a long time, but at these speeds, it more than triples what is now possible within Australia," he says. "This new addition to our facility will allow us to test the types of vehicle that could one day travel from Australia to Europe in two hours."

The reflected shock tunnel operating mode of X3 is known as X3R. At the heart of the tunnel is a device called a free-piston driver, a concept invented by Australian hypersonics pioneer, the late Professor Ray Stalker (science.org.au/files/userfiles/fellowship/memoirs/documents/raymond-john-stalker-hr.pdf). Within that driver, in just a few hundred milliseconds, a 500mm diameter piston, weighing more than half a tonne, is accelerated down a 14m tube to nearly 500km per hour.

"Exploration of space relied on the ground testing of hypersonic vehicles through facilities like X3 and X3R," Dr Gildfind explains. "The original X3 configuration is optimised for the most extreme flight speeds imaginable and can simulate planetary entry conditions well beyond 40,000km per hour, for about one millisecond. With X3R, we operate the machine in a different way,





LEFT Representative wedge shape at hypersonic speed.

BELOW LEFT UQ X3R Piston.

BOTTOM LEFT UQ's X3R reflected shock tunnel.

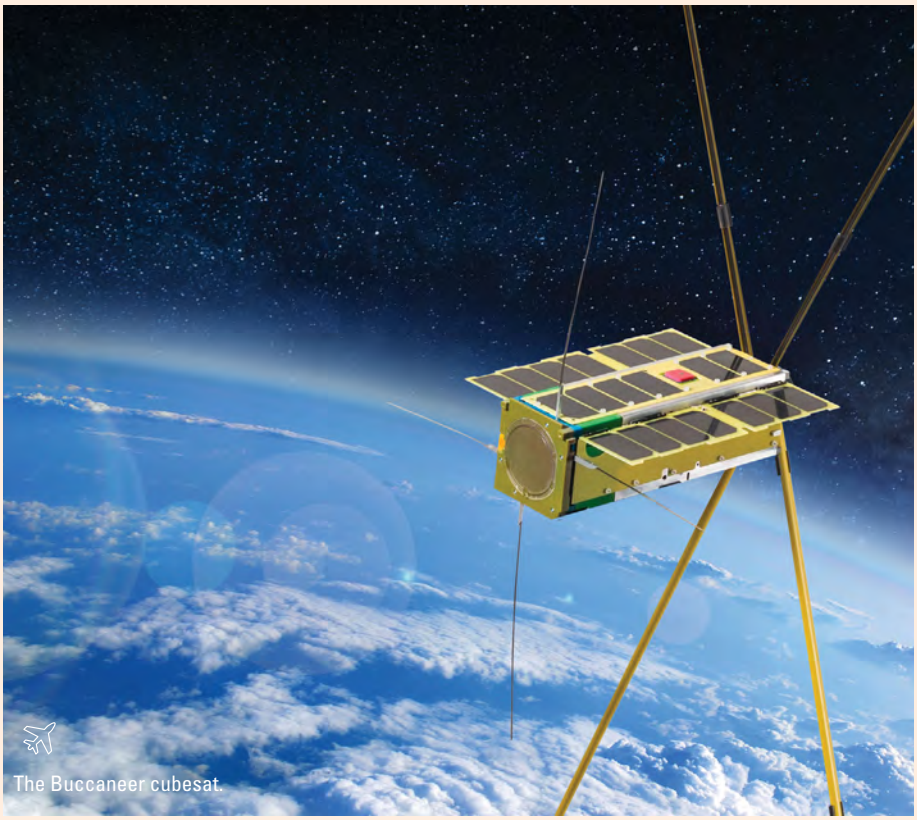
which can extend the test time to over 10 milliseconds; while this restricts the maximum speed to around 8,000km an hour, it's that lower speed that will allow us to make big advances in terrestrial hypersonic flight.

"X3R is a transformational capability improvement for Australia, which makes it possible for researchers to investigate fundamental hypersonic phenomena, of which we historically have a great legacy, at a larger scale. This has only been made possible by combining the expertise and resources of both UQ and the Department of Defence, Science and Technology (DST)."

This development is the latest outcome of long-term research and educational collaboration between UQ and DST, covering hypersonic ground and flight testing and the development of transformational flight technologies.

The X3R facility will be relocated to a new DST laboratory at Eagle Farm in Brisbane and will become a focal point for national and international research partnerships in hypersonic knowledge.

"This could lead to significant breakthroughs in hypersonic technologies in Australia, and will provide the vital infrastructure Australia needs to support our burgeoning space industry," says Dr Gildfind.



The Buccaneer cubesat.

DST AIMS HIGH

DEFENCE IS SPENDING BIG ON SPACE-ENABLED TECHNOLOGIES – WITH SIGHTS SET ON BECOMING A WORLD-CLASS OPERATOR OF A RESILIENT, HIGHLY CONNECTED SYSTEM OF SATELLITES.

THERE'S A LOT MORE to space than just a hi-tech bandwagon. Defence plans to invest about $19 billion up to 2026 on space capabilities with a focus on communications, surveillance and situational awareness and navigation.

Those functions are addressed by several of the 10 STaR Shots — disruptive Defence Science and Technology (DST) research priorities announced last August by Chief Defence Scientist Tanya Monro.

Three StaR Shots, in particular, focus on the resources space-enabled technologies can deliver to the ADF: a space technology intelligence cloud; next-generation command and control; and quantum-assured position, navigation and timing.

The word "navigation" doesn't do the science justice: position, navigation and timing describe the ability to navigate with centimetric accuracy and to locate

potential adversaries with similar accuracy, both of which depend on modern surveillance systems running atomic clocks of similar accuracy to the GPS system, or better.

The 2016 Defence White Paper called for enhanced space capabilities, says Andrew Seedhouse, head of DST's National Security and Intelligence, Surveillance and Reconnaissance Division. DST already has an outline 10-year plan for pivoting into what Seedhouse calls "smart space". His vision is for the ADF to become a world-class operator of a resilient, highly connected system of satellites, communications links, sensors, ground stations and processors, often operating autonomously so they can dodge space debris or other orbiting bodies.

Despite being Australia's biggest spender on space communications and surveillance services, Defence has had little direct experience of designing satellites and payloads or deploying and operating those assets once in orbit.

DST's Buccaneer "cubesat" program, designed in partnership with the University of NSW at the Australian Defence Force Academy, is helping to change that. The 10 x 10 x 34cm Buccaneer 1 cube satellite was launched into low earth orbit from Vandenberg Air Force Base, California in 2017. The launch provided Defence personnel with the experience of running a complete space mission and validated a couple of key technologies that included a UNSW-developed GPS receiver and camera, a DST-developed 3m cruciform antenna and a means of stabilising a satellite with an asymmetric payload.

Buccaneer 2 will be more complex but will benefit from the ADF's higher levels of experience. As well as the crucial antennas and stabilisation system, it will include a high-frequency receiver to help calibrate the ADF's Jindalee Operational Radar Network (JORN) over-the-horizon radar. Buccaneer 2 will also incorporate an optical communications payload – a laser link that's inherently more secure than a radio link. Future optical links will be more secure still, thanks to quantum encryption, one of DST's 10 technology priorities under the Next Generation Technologies Fund.

Small cube satellites are a good starting point, says Seedhouse, but military payloads are frequently bigger and more complex. Bigger satellites are now almost a commodity, he says, citing the OneWeb ARROW, a 60 x 60 x 60cm satellite with a 60kg payload. Mass-produced by Airbus and OneWeb, ARROW satellites will, from 2020, form a 600-strong low-earth-orbit constellation providing highspeed global internet access.

If they're cheap enough, small satellites can be replaced quickly, says Seedhouse. Some satellites last barely three years before their orbits decay or they run out of stabiliser propellant.

Economic and rapid replacement redefines high performance; technology becomes dated incredibly quickly and if it embodies security systems, high-performance processing, advanced sensors and communication systems, satellites must be cheap so they can be replaced regularly. That ensures they remain high-performance systems. A big, expensive satellite needs a long service life to deliver a return. It quickly becomes redundant as its technology becomes obsolete. That makes it a low-performance system.

The commoditisation of satellites and launchers means it's far better to invest in areas Australia has either a technical advantage or a specific need such as tracking space debris and smart payloads such as multi-function radar and radio antennas.

On-board processing is another goal, letting the satellite process imagery in real time rather than consume precious bandwidth and power downloading terabytes of raw data for processing on the ground. Leveraging the STaR Shot research, DST's goal is to transition Defence from simple customer to adept creator and manager of space technology and therefore master of its own destiny.

• This article, written by Gregor Ferguson, was first published in the Weekend Australian Defence Supplement. *Gregor Ferguson is an innovation communicator and former editor of* Australian Defence Magazine.

ELECTRIC AIRCRAFT ON THE HORIZON

ELECTRIC CARS, TRAINS, TRAMS & BOATS ALREADY EXIST. SO WHY DON'T WE HAVE ELECTRIC PLANES?

WHY DO WE HAVE electric cars and trains, but few electric planes? The main reason is that it's much simpler to radically modify a car or train, even if they look very similar to traditional fossil-fuel vehicles on the outside. Land vehicles can easily cope with the extra mass from electricity storage or electrical propulsion systems, but aircraft are much more sensitive.

For instance, increasing the mass of a car by 35 percent leads to an increase in energy use of 13-20 percent. But for a plane, energy use is directly proportional to mass: increasing its mass by 35 percent means it needs 35 percent more energy (all other things being equal).

But that is only part of the story. Aircraft also travel much further than ground vehicles, which means a flight requires far more energy than an average road trip. An aircraft must store, on board, all the energy needed to move its mass for each flight (unlike a train connected to an electrical grid). Using a heavy energy source therefore means more energy is needed for a flight, which leads to extra mass.

An experimental flying taxi, with a vertical take-off-and-landing, was unveiled in 2019 at a show in Las Vegas. It is powered by a hybrid-electric system.
Photo courtesy Bell/Cover Images.

For an aircraft, mass is crucial, which is why airlines fastidiously weigh luggage. Electric planes need batteries with enough energy per kilogram of battery mass, or the mass penalty means they simply can't fly long distances.

Despite that, electric aircraft are on the horizon – but you won't be seeing electric 747s any time soon.

Today's best available lithium ion battery packs provide about 200 watt-hours (Wh) per kilogram, about 60 times less than current aircraft fuel. That type of battery can power small electric air taxis with up to four passengers over a distance of about 100km. For longer trips, more energy-dense cells are needed.

Short-range electric commuter aircraft that carry up to 30 people for less than 800km, for instance, specifically require between 750 and 2,000Wh/kg, which is some 6-17 percent of kerosene-based jet fuel's energy content. Larger aircraft require increasingly lighter batteries. For example, a plane carrying 140 passengers for 1,500km consumes about 30kg of kerosene per passenger. With current battery technology, almost 1,000kg of batteries is needed per passenger.

To make regional commuter aircraft fully electric requires a four to tenfold reduction in battery weight. The long-term historical rate of improvement in battery energy has been about three to four percent a year, doubling roughly every two decades. Based on a continuation of that historical trend, the fourfold improvement needed for a fully electric commuter aircraft could potentially be reached mid-century.

While that may seem an incredibly long wait, it is consistent with the timescale of change in the aviation industry for both the infrastructure and aircraft design lifecycles. A new aircraft takes about five to 10 years to design and will then remain in service for two to three decades. Some aircraft are still flying 50 years after their first flight.

Does this mean long-distance flying will always rely on fossil fuels?

Not necessarily.

While fully electric large aircraft require a major, yet-to-be-invented shift in energy storage, there are other ways to reduce the environmental impact of flying.

Hybrid-electric aircraft combine fuels with electric propulsion. That class of aircraft includes design without batteries, where a complimentary electric propulsion system serves to improve the thrust efficiency, reducing the amount of fuel needed.

Hybrid-electric aircraft with batteries are also in development, where the batteries may provide extra power in specific circumstances. Batteries can then, for instance, provide clean take-off and landing to reduce emissions near airports.

Electric planes are also not the only way to reduce the direct carbon footprint of flying. Alternative fuels, such as biofuels and hydrogen, are also being investigated.

Biofuels, which are fuels derived from plants or algae, were first used on a commercial flight in 2008 and several airlines have performed trials with them. While not widely adopted, significant research is currently investigating sustainable biofuels that do not impact freshwater sources or food production.

While biofuels do still produce CO2, they don't require significant changes to existing aircraft or airport infrastructure. Hydrogen, on the other hand, requires a complete redesign of the fuelling infrastructure of the airport and also has a significant impact on the design of the aircraft itself.

While hydrogen is very light – hydrogen contains three times more energy per kilogram than kerosene – its density is very low, even when stored as a liquid at -250°C. That means fuel can no longer be stored in the wing but needs to be moved to relatively heavy and bulky tanks inside the fuselage. Despite these drawbacks, hydrogen-fuelled long-distance flights can consume up to 12 percent less energy than kerosene.

• This article, written by Dr Dries Verstraete, was first published by The Conversation. Dr Verstraete is an aerospace expert from the University of Sydney's School of Aerospace, Mechanical and Mechatronic Engineering.

WORDS Sean Pierce | PHOTOS Rob Power

EVOLUTION OF THE PHOENIX

UNMANNED AERIAL TARGETS HAVE BEEN OPERATING IN AUSTRALIA SINCE THE EARLY 1950S.

THE AIR AFFAIRS AUSTRALIA Phoenix Jet is a remotely piloted aircraft that operates as an unmanned aerial target (UAT) in support of the Australian Defence Force (ADF) weapons tracking and firing programs. The Phoenix UAT is often referred to as a drone, which may seem like a new phenomenon in today's aviation world, but UATs have actually been operating in Australia since 1952. The first UAT, or target drone, was the Jindivik built by the Government Aircraft Factories and deployed to the Woomera Test Range, South Australia and the Jervis Bay Range Facility, NSW.

The Jindivik (an Aboriginal word meaning "the hunted one") was extensively used by the Royal Australian Navy and the Royal Australian Air Force for missile test and evaluation, and combat training.

Many Jindivik's were intentionally shot down, so it was most desirble that they be remotely controlled (radio controlled). Although very successful, the Jindivik was extremely costly to operate; it required a crew of 35 and could not be launched without a runway.

In 1998, the Jindivik was replaced with a state-of-the-art target drone called Kalkara ('storm bird"). The Kalkara required only 12 people to operate and was launched using a rocket motor that could accelerate the vehicle from 0 to 460km/hr in 2.5 seconds. The ability to launch Kalkara from a standing start made it extremely versatile as it could be deployed to locations without runway infrastructure. A parachute system was used for target recovery and it was normally splashed into the ocean where it was quickly picked up by a surface vessel.

Costing $1.2M each, Kalkara was too expensive to be directly targeted and damaged or destroyed, so were instead used to tow smaller expendable targets from a 1,200m cable. That adaption prevented any form of evasive manoeuvre, which was detrimental to providing a real threat simulation.

Air Affairs Australia (AAA), based in South Nowra, NSW, was heavily involved in the Australian UAT business, operating the very much smaller Banshee target, and also providing towed targets to the Kalkara project, target reeling machines and other target related services.

In 2004, AAA recognised an opportunity to develop a brand-new, cost-effective target that would utilise the latest autopilot and engine technology available at that time.

The Phoenix Jet UAT project, launched in 2005, required AAA to design and build a launcher, a target vehicle (UAT) and a Command and Control (C&C) station. A sleek delta wing design with elevon control surfaces, a single centrifugal-flow turbojet and a highly advanced auto-pilot navigation system were selected for maximum UAT performance. The launcher selected was a catapult type able to accelerate a 70Kg UAT to 55kts in one second.

The C&C station was housed in a mobile transit van and included radio communications, navigation system interface, command and control functions and a weather station.

OPPOSITE Phoenix Jet uses a parachute system for recovery.

LEFT Phoenix Jet on a mobile catapult launcher.

Phoenix Jets ready for launch.

Flight trials began in December 2005 at Marulan, NSW, with the UAT initially fitted with undercarriage. The trials proved very promising and the project proceeded to introduce the catapult launcher and fully commissioned C&C station; a complete unmanned aerial system (UAS).

By October 2007, the Phoenix UAS had completed 16 test and evaluation flights and the Australian Army awarded its first contract to AAA to provide the Phoenix UAS for target applications at the Womera Test Range. That operation proved successful and with much valuable information obtained from those initial operational flights, additional test flights were conducted at Marulan to fine-tune the immature system.

From 2008 until 2010, the employment of UAT's by the ADF diminished as the Kalkara was phased out of service. Unperturbed by the lack of activity, AAA continued with refinement of the Phoenix UAS and moved operational flight tests to a purpose-built facility at Cobar, NSW.

In November 2010, the New Zealand Navy (RNZN) requested a demonstration flight. In February 2011, the Phoenix UAT was successfully presented to the RNZN guided missile frigate, *HMNZS Te Kaha*. Following that very successful deployment, the ADF became more interested in the capability of the Phoenix UAS and AAA was awarded its first RAN project in May 2011.

In September of 2013, the Phoenix UAS was used to support RAAF air-to-air missile operations in the Eastern Exercise area which were again extremely successful, and Phoenix was becoming widely accepted by the ADF as the new Australian UAS of choice.

Following the success in Australia and NZ, AAA was awarded a contract with the Korean navy (ROKN) in 2017 to supply a complete Phoenix target system for deployment on its new multi-purpose training ships. That contract proved very challenging as it required a higher top speed of 330kts and a sea-skimming capability of 7m minimum altitude. In order to meet those new requirements, AAA developed a new high-performance Phoenix UAT, which incorporated a more powerful jet engine and a RADAR altitude hold system. The enhanced Phoenix HP was successfully trialled in Korea and was formally accepted into service with the ROKN in August 2017.

From 2018, the Phoenix HP became the standard UAT in AAA production as its extra performance was very much appreciated by all customers. On the 2 April 2018, the Phoenix UAS completed its 200th flight, the system has been operated in four countries and employed against many missile and weapon types. The success of the Phoenix UAS can be attributed to its cost-effective design and its ability to be deployed to remote bases and on board ships.

At the 2017 Avalon Airshow, AAA announced the establishment of a Memorandum of Understanding (MoU) for collaboration with Kratos Unmanned Systems Division. The MoU builds on an existing longstanding manufacturing agreement between the two companies for AAA to provide parts and payloads for the full range of Kratos drones deployed in Australia.

The MoU enables AAA and Kratos to offer a selection of UAS ranging from the low-cost Phoenix to tactical and high-performance UATs to support a number of test and training applications for the ADF.

VALKYRIE FLYING HIGH

IT MAY BE A TARGET DRONE, BUT WITH ITS STEALTH TECHNOLOGY AND ABILITY TO CARRY UP TO 270KG OF MUNITIONS, KRATOS' VALKYRIE CLOSELY RESEMBLES A REAL COMBAT AIRCRAFT.

THE XQ-58A VALKYRIE was designed by Kratos Unmanned Aerial Systems, a manufacturer of target drones for the US Armed Forces. Kratos targets, designed to mimic enemy jet fighters, are big as far as drones go. Evidently, it was a short leap to evolve a drone pretending to be a fighter to a drone with some combat fighter capabilities.

According to the US Air Force, the XQ-58A was a joint effort between Kratos and the Air Force Research Laboratory (AFRL), announced in July 2016 under the latter's Low Cost Attritable Aircraft Technology (LCAAT) program.

The Valkyrie requirement called for a craft capable of Mach 0.9 speeds for short periods, to have a 1,500-nautical-mile range, and be able to carry at least two GBU-39 small diameter bombs. It was required to feature "extreme agility" for missile avoidance. The Low Cost Attritable Strike Demonstration (LCASD) solution was to be relatively inexpensive: $3 million each for the first 99, $2 million each if you buy more than 100.

The contract for the Valkyrie specified a drone "capable of low-altitude 'nap of the earth' flying, high-altitude cruise, defensive counter-air manoeuvres, offensive counter-air manoeuvres, and suppression and destruction of enemy air defences". As of early February, the XQ-58A had executed four successful test/demonstration flights, totally more than five hours.

Kratos' Valkyrie has been awarded the 2020 Aviation Week Network's Laureate Award for Technology & Innovation in the defense sector. Announcing the award, Steve Fendley, president of Kratos Unmanned Systems Division, said: "The Valkyrie, which progressed from clean sheet to flying aircraft just 30 months after contract award, perfectly exemplifies the value that Kratos' model and commitment to delivering affordable, right-technology solutions can bring to our Armed Forces. Kratos, along with our AFRL partner, is honored to be recognised and receive Aviation Week's prestigious Laureate Award."

The Air Force requirement also called for the solution to be "runway independent". Kratos's target drones are launched from the back of trucks/trailers and ships at sea using Rocket Assist Take-Off (RATO) motors. Once their mission is over, they deploy parachutes and float back to earth for recovery. That means that the XQ-58A can be launched from a convoy of trucks remote from sprawling air bases, both protecting the bases from attack and freeing up the runway for manned aircraft.

The XQ-58A employs a degree of stealth design/technology, with the rear exhaust nozzle buried within the fuselage, presumably to mask its heat signature. That's a feature that wasn't in the original specifications. Combined with the ability to carry up to 270kg of munitions internally, such as a pair of 113kg small diameter bombs, the Valkyrie closely resembles a real, combat aircraft.

Kratos XQ-58A Valkyrie.

XQ-58A "VALKYRIE"

WINGS VOLUME 72 NO.1

XQ-58A

"VALKYRIE"

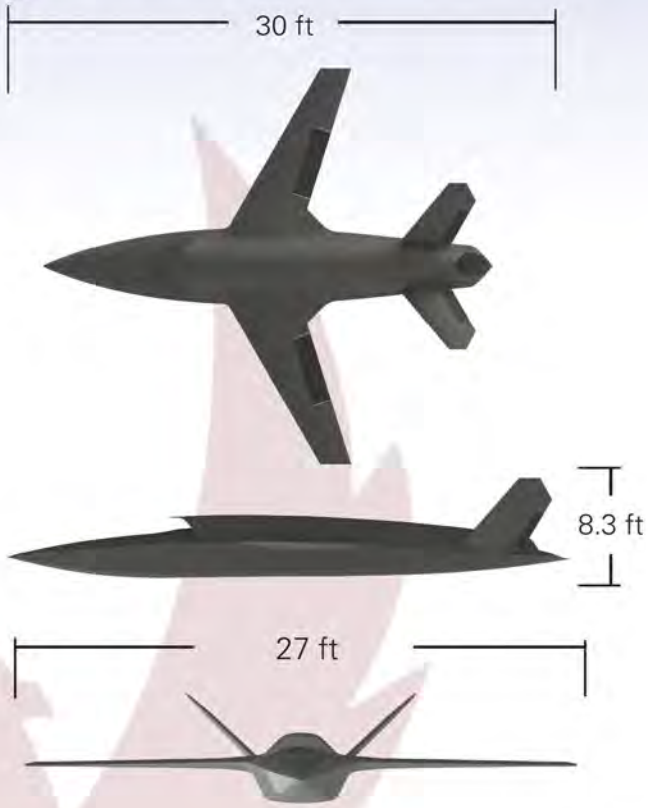
TEST FLIGHTS COMPLETED 2019

XQ-58A Valkyrie

Representing a clean-sheet, low-cost tactical UAS, the XQ-58A is changing the paradigm for tactical UAS technology. The XQ-58A delivers a combination of long-range, high-speed, and maneuverability along with the capability to deliver a mix of lethal weapons from its internal bomb bay and wing stations.

Runway-independence and extreme range deliver maximum operational flexibility and utility to the war fighter.

Please contact Kratos Unmanned Aerial Systems for more information about the integration of customer-furnished pay-loads.



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A FIFTH-GENERATION

SUPER BASE

OFFICIALLY OPENED IN 1954 AS A RAAF BASE, EDINBURGH DEFENCE PRECINCT IS NOW THE LARGEST DEFENCE ESTABLISHMENT IN SOUTH AUSTRALIA.

AP-3C Orion aircraft from No.10 Squadron taxis past a No.11 Squadron P-8A Poseidon aircraft at RAAF Base Edinburgh. Photo by CPL Brenton Kwaterski.

THE DEFENCE PRESENCE AT EDINBURGH, South Australia dates back to World War II. In 1942, the largest munitions plant in the Southern Hemisphere was established at Penfield, a small village to the south of the Base. Between 1946 and the mid-1960s, several thousand Australians and British nationals were based at Penfield, Woomera and Mallala (a WWII RAAF base located 60km north of Adelaide) to support Australian and British weapons research and development.

RAAF Base Edinburgh was formally opened by Prince Philip, Duke of Edinburgh, on 22 March 1954 and has continued the proud South Australian legacy, by establishing itself as an important contingent of the greater Adelaide community.

After the British began withdrawing from SA in the mid-1960s, 11 Squadron moved from RAAF Base Townsville to RAAF Base Edinburgh with its new P-3B Orion aircraft. In 1975, 92 Wing was established, and comprised both 11 Squadron and 10 Squadron, which also relocated to Edinburgh with the new AP-3C Orion.

In the late 1970s, a decision to make Edinburgh the primary base for RAAF's maritime capability led to the construction of new facilities. Since then, other RAAF Units have been established at, or moved to the Base and RAAF Base Edinburgh is now home to intelligence, radar, electronic warfare, security, air operations support and flight test functions of the ADF.

Early in the second decade of the 21st century, Australian Army elements began relocating to Edinburgh with the reformation of 7th Battalion Royal Australian Regiment followed by the relocation of 1st Armoured Regiment in 2017.

Today, the Edinburgh Defence Precinct is the largest Defence establishment in South Australia, comprising RAAF Base Edinburgh, Defence Science Technology Group, Edinburgh Parks and the Woomera Range Complex. More than 6500 RAAF and Army personnel, Defence civilians and contractors work across the operationally focused joint Defence establishment.

TRANSFORMING THE BASE

The facilities and infrastructure at RAAF Base Edinburgh have undergone a major transformation in recent years. Once a narrow road with 1950s buildings on one side and fields on the other, the main thoroughfare, McNamara Drive is now an attractive boulevard flanked on both sides by appealing modern structures.

Major garrison-support facilities, including combined messing, accommodation areas, gym and indoor pool, community commercial and training areas were constructed from 2009-10, as were facilities for Army and joint Units relocated to RAAF Base Edinburgh.

The redevelopment of the Base is far from finished. Current works are widespread and are emphasised by construction of new infrastructure and facilities to support the recently acquired P-8A Poseidon maritime patrol aircraft. Those works will be completed in mid 2020, but major construction projects will continue well into the next decade to support Army armoured fighting vehicles and planned Air Force capabilities, including the MQ-4C Triton Unmanned Aircraft System (UAS), MC-55A Peregrine airborne electronic warfare capability and MQ-9 Reaper variant, Australia's first armed UAS.

The works will deliver a multitude of new aircraft hangars, workshops, vehicle shelters and hardstands, operations centres, training centres including simulators, headquarters and working accommodation, along with extensive redevelopment of the airfield runways, taxiways and aprons. In conjunction with those works, a large base-wide project will commence in early 2021 to refresh power, water, sewerage and stormwater infrastructure.

The exciting large-scale transformation that has taken place at Edinburgh over the last 10 years still has a way to go.

LEFT AP-3C Orion flying across the new 92WG facilities constructed in 2019 for the new P8A Poseidon. Photo by CPL David Cotton.

BELOW RAAF and Australian Public Service personnel at Air Warfare Centre headquarters, RAAF Base Edinburgh. CPL David Cotton.

DEFINING A 5TH GENERATION AIR FORCE

Further highlighting the demonstrated stability and capacity for growth of the region, the Air Warfare Centre (AWC) Headquarters is located at RAAF Base Edinburgh and is supported by a large integrated workforce including Air Force, Army, Navy, Public Service and Defence Industry personnel.

Established in 2016 as a key element of the transformative Plan Jericho vision for a 5th Generation Air Force, the AWC is now internationally recognised as an integrated warfare centre of excellence; an impressive result in a matter of years.

Plan Jericho is the Chief of Air Force's plan to transform Air Force into a fighting force that capitalises on the high technology systems being introduced in the next few years.

Solving complex operational problems and delivering the best possible solutions is at the heart of AWC's business. Its mission is to "ready the war-fighter" for complex warfare in a 5th Generation context across multiple domains including air, land, sea, space, the electromagnetic spectrum, and cyber-space. The AWC engages broadly to scope, test and deliver innovative alternatives in those case where obvious solutions do not exist.

The AWC drives and supports the Australian Defence Force to innovate and integrate, while delivering assured and operationally relevant tactics, training, intelligence, analysis, and qualified products and services. It closely coordinates and cooperates across not only Air Force, but joint and partner nations, as well as with the Defence Science and Technology Group, industry and academia partners.

ABOVE MQ-4C Triton.

LEFT Optical and Mechanical Systems Technician Trevor Scott shows Research Engineer Rachel Owen the RAKIMO (Rate Assisted Kinematic Mount) in operation.

BELOW RIGHT Launch of rocket to test hypersonic speed, Woomera, May 2016.

WOOMERA RANGE COMPLEX

First established in the 1950s to support British-Australian weapons development, Woomera has become integral to the evolution of a 5th generation Air Force. Located about six hours drive north of Adelaide and covering over 120,000 square kilometres, it is one of the largest over-land test ranges in the world.

The vast Woomera Range Complex (WRC) includes the Woomera Prohibited Area, the Woomera Test Range (WTR), RAAF Base Woomera (including airfield and township), Woomera Restricted Airspace, Woomera Camp Rapier and the Nurrungar Test Area. While the Air Force Test Ranges Squadron manages the test and trials conducted on the range (on behalf of the AWC), No.20 Squadron manages RAAF Base Woomera, and Estate and Infrastructure Group manage garrison support functions.

Defence maintains a shared use arrangement for WRC under a coexistence agreement that includes traditional owners, pastoralists, the resources sector and tourism operators, coordinated through the Woomera Prohibited Area Coordination Office (WPACO).

The WTR has been reserved to test Defence capabilities including weapons, aircraft performance and handling qualities, Unmanned Aerial Systems (UAS), and electronic warfare systems. It provides a highly specialised operations environment in support of directed national and whole-of-government objectives for test and qualification of war material.

The WTR uses special equipment, such as high-speed cameras and optical trackers, to control test parameters, capture time, space, position information and behavioural characteristics of the system under test and to support test safety objectives. Its unique features provides Defence and its allies with a capability for controlled, secure and safe test and evaluation, and research and experimentation activities through the provision of a large land mass and unencumbered airspace.

TEST AND EVALUATION

Located within the AWC, the Test and Evaluation Directorate (TED) comprises: Aircraft Research and Development Unit (ARDU) accountable to the Chief of Air Force for delivering flight test expertise; Air Warfare Engineering (AWE); Institute of Aviation Medical (IAM); and Aeronautical Information Services (AIS). TED integrates with operational Units to generate capability through flight test and evaluation for the force-in-being, objective and future forces.

TED Units maintain a unique set of skills and experience stemming from early research of aerodynamics, aircraft performance, weapon employment programs, and assessments of WWII enemy airborne capabilities. Currently, the primary focus of ARDU and AWE is planning, executing and reporting on flight test and evaluation of capabilities reaching across the spectrum of air power. IAM provides airborne medical research and evaluation that feeds into force element understanding of the limitations and strengths of humans within aircraft systems, while AIS generate and evaluate aeronautical flight planning and support products for use by aircrew and planning staff.

RIGHT Space Operations Section of No.1 Remote Sensor Unit. Photo by CPL Craig Barrett.

BELOW An F/A-18A Hornet from ARDU carries a pair of JDAM-ER guided weapons on the way to Woomera Test Range. Photo by CPL David Gibbs

Air-to-Air refuelling qualification tests between KC-30A Multi-Role Tanker Transport and E-7A Wedgetail conducted by ARDU. Photo by FLTLT Drew Abbott.

Hypersonic research rocket launch - Woomera May 2016

THE ADF'S ISR HUB

Over the past 10 years, RAAF Base Edinburgh has become a major intelligence, surveillance and reconnaissance (ISR) hub for the ADF, with AWC, 92 Wing, and No.1 Remote Sensing Unit (1RSU) located at the Base.

Capable of operating 24 hours a day, 1RSU is staffed by Air Force and Navy personnel. BAE Systems contractors provide technical and training support for the mission systems employed by the Unit. As a member of No.41 Wing, 1RSU conducts air, maritime and space surveillance using a combination of terrestrial and space-based sensors to develop situational awareness for a range of customers. Formed in July 1992, the Unit commenced operations in 1993 using the Jindalee Over-the-Horizon Radar (OTHR) at Alice Springs, NT which had been operated locally by Air Force technicians since 1986.

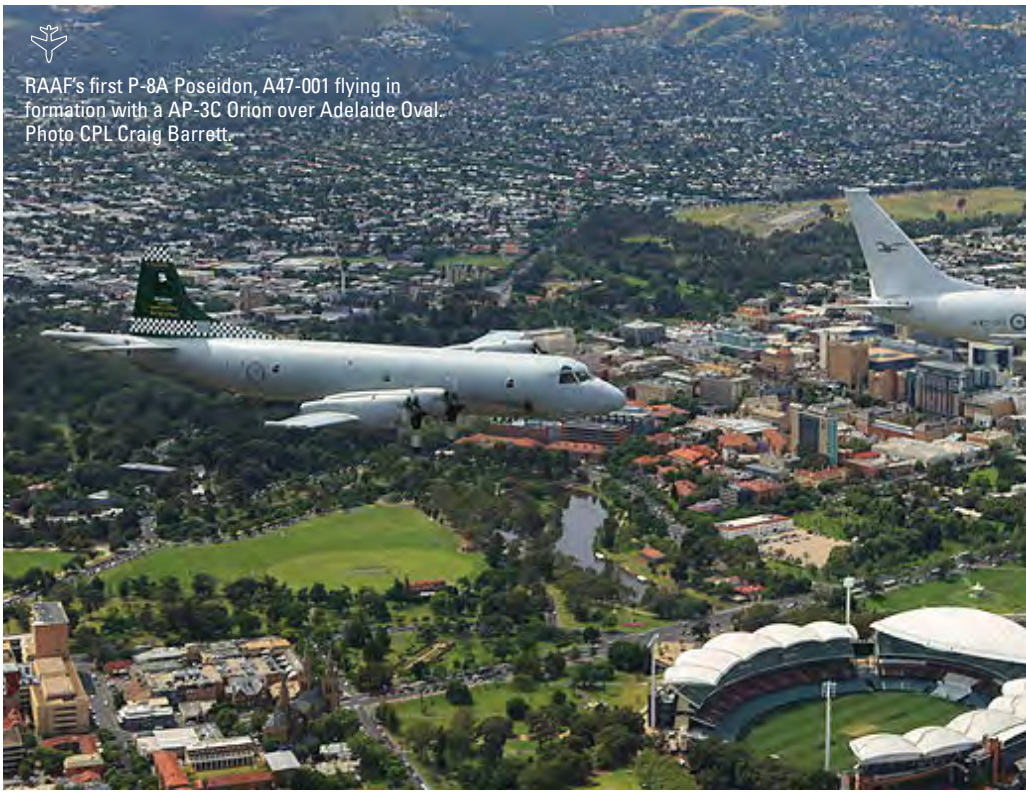
In 2003, a further two OTHRs were commissioned in Longreach, Qld, and Laverton, WA, completing what is known as the Jindalee Operational Radar Network (JORN), a layered surveillance network. 1RSU remotely operates the JORN from RAAF Base Edinburgh, conducting surveillance of Australia's northern approaches and collecting, analysing and disseminating data into the ADF's Common Operating Picture.

1RSU also remotely operates a C-Band Space Surveillance Radar. A United

States Air Force asset, the C-Band radar was relocated to Exmouth, WA, to help fill a coverage gap in the US Space Surveillance Network (SSN). The radar is designed to detect, track and help to identify objects in low earth orbit and medium earth orbit, and feed that information into the SSN. It has the ability to track a variety of space objects, from large satellites and rocket bodies down to small items such as rocket components.

Additionally, 1RSU undertakes battlespace characterisation using the Space Based Infra-Red System Australian Mission Processor, delivered under Joint Project 2057. That capability is comprised of ground-based hardware and software to process data from a constellation of US satellites.

1RSU also draws upon military and civil air traffic radars and data, and other sensors within the RAAFs network to produce a Recognised Air Picture, which provides situational awareness of aircraft movements in an area of interest to tactical and operational customers.



RAAF's first P-8A Poseidon, A47-001 flying in formation with a AP-3C Orion over Adelaide Oval. Photo CPL Craig Barrett.

FROM ORION TO POSEIDON AND TRITON

The Air Force's AP-3C Orion aircraft has been an icon of the South Australian skies, known not only for its maritime surveillance and anti-submarine roles, but also for its vital search-and-rescue support. In 2018, the Orion reached 50 years of distinguished service and has been replaced by the P-8A Poseidon aircraft, again based at RAAF Edinburgh.

The RAAF is acquiring 12 P-8A Poseidon aircraft to be operated by No.11 Squadron. The first P-8A arrived in Australia in November 2016.

The Poseidon's primary roles include the detection and response to, naval surface and submarine threats, surveillance and reconnaissance and search and rescue. It is a potent, highly versatile, reliable and modern aircraft based on the commercial Boeing 737-800 aircraft. It can undertake sophisticated operations at great distances and is able to efficiently patrol Australia's extensive maritime approaches and areas of interest.

Plan Jericho will deliver an integrated data processing system for the P-8A that is more agile, has extended reach, gathers more data and distributes refined Surveillance and Intelligence products more quickly than ever before.

Further, under Plan Jericho, the RAAF will continue to develop and evolve new operating concepts, support arrangements and sustainment processes to best exploit the Poseidon's capabilities when operated with the MQ-4C Triton Unmanned Aircraft System (UAS) as part of an integrated Maritime Intelligence, Surveillance and Reconnaissance Family of Systems.

The MQ-4C Triton UAS is a high-altitude, long-endurance aircraft which will be used for maritime patrol and other surveillance roles. Able to sustain missions of up to 24 hour duration, Triton is equipped with a sensor suite that provides a 360-degree view of its surroundings for more than 2,000 nautical miles. The Government committed to the acquisition of seven MQ-4C Triton platforms in the 2016 Defence White Paper and delivery is expected early in this decade.

Cementing the Base's role in delivery of a 5th Generation Air Force, the Triton will be operated from Edinburgh and flown by a two-man crew of qualified RAAF pilots from a ground station embedded at the Base. Operational doctrine will see the Triton compliment the P-8A Poseidon patrol and surveillance capabilities and together, the two platforms will provide Australia with a highly advanced maritime patrol and surveillance capability.

P-8A Poseidon with Harpoon Missiles.

Triton will lead to additional significant investment in new facilities and infrastructure, a proportion will be spent in South Australia. Indeed, through-life support requirements for Triton should create approximately $20m annually in further opportunities for Australian companies.

BELOW Soldiers of the 1st Armoured Regiment with Commander 1st Brigade, Brigadier Matt Pearse, AM during the Ready Battle Group Parade, RAAF Base Edinburgh. Photo by CPL Shane Kelly.

7 RAR soldiers conduct an assault during Battle Group Lion's live fire Warfighter activity at Shoalwater Bay Training Area, Qld. Photo by CPL Carla Armenti.

THE ARMY AT RAAF EDINBURGH

South Australia has also had a long and proud association with the Australian Army and is home to elements of one of the Army's three Combat Brigades including the 1st Brigade's only ground-based air defence unit.

The Army's presence in SA includes the 1st Armoured Regiment at Chauvel Lines and the 7th Battalion, Royal Australian Regiment (7 RAR), of the 1st Brigade (Adelaide) based at the Horseshoe Lines at RAAF Base Edinburgh, 6th Brigade's 16th Air Land Regiment based at Woodside Barracks and the Reserve 9th Brigade, headquartered at Keswick Barracks with Bases spread across the state.

An element of the 1st Combat Service Support Battalion, the 1st Combat Service Support Team provides logistic support to the 1st Brigade's elements in SA. Almost 1,200 soldiers of the 1st Brigade, 7 RAR, 1st Armoured Regiment and the 1st Combat Service Support Team and their families now call RAAF Edinburgh home after relocating from Darwin in recent years.

The 1st Armoured Regiment uses its M1A1 Abrams tanks and Australian Light Armoured Vehicles to provide firepower, manoeuvre and shock capability to the Brigade. The Regiment trains to achieve world's best practice in armoured warfare, across the spectrum of operations by excelling at the basics of mounted and dismounted combat.

7 RAR is an infantry battalion of the 1st Brigade and is the largest of all the Regular Units of the ADF based in SA. The Regiment was raised on 1 September 1967 for operations in South East Asia, amalgamating to form 5/7 RAR in 1973, and de-linking in 2006 to become 7 RAR once again. Since then, 7 RAR has deployed on multiple operations to the Middle East, and again to South East Asia. Through 2020, the 1st Brigade will continue as the Ready Brigade, able to deploy to conflict or respond to disaster at short notice.

LEFT Australian Army M1A1 Abrams tanks live fire activity as part of the Warfighter activity at Shoalwater Bay Training Area, Qld. Photo by CPL Carla Armenti.

A FINAL ADVENTURE

HAVING CONCLUDED THEIR PIONEERING 1919 FLIGHT FROM ENGLAND TO AUSTRALIA, INTREPID AIRMEN ROSS SMITH, HIS BROTHER KEITH AND MECHANICS WALLY SHIERS AND JIM BENNETT CROSS AUSTRALIA FROM DARWIN TO ADELAIDE, COLLECTING THEIR PRIZE IN MELBOURNE ALONG THE WAY.

THE PORT PROPELLER was showing signs of splitting but I thought it would last until we reached Sydney where we could get another. All things considered I thought it best to get on as quickly as possible, because had we remained at Port Darwin for any length of time it is highly probable the Vimy, standing out in the open, would have been severely damaged in one of the tropical storms that occur here frequently at this time of year.

The Minister of Defence at Melbourne had arranged petrol and oil supplies for us at various points and the first town we would reach after leaving Port Darwin was Cloncurry, in North-western Queensland – a distance of about 1,000 miles [1,610km]. The maps of all that northern part of Australia are bad and show very little detail, but we arranged to get some information about various landmarks from some stockmen who had recently returned from droving a mob of cattle from Darwin to Cloncurry.

The day before we left Port Darwin, Captain Wrigley and Lieutenant Murphy of the Australian Flying Corps arrived from Melbourne in an old BE.2e machine. They had come up to meet us and had achieved a remarkable performance in having flown so far in a machine four years old.

Our first mechanical troubles of the whole journey began soon after leaving Darwin. We were following the telegraph line which runs overland from Darwin to Adelaide; it was terribly hot and below us stretched a limitless expanse of undulating scrub country. After about four hours of very uncomfortable flying, valve trouble developed in the starboard engine and I decided to land on a dried-up swamp a few miles ahead. It turned out to be very rough ground, but we got down safely and Shiers soon had the engine right again.

Photos courtesy of the State Library of South Australia.

WARLOCK PONDS

There was a good water hole at one side of the swamp and as flying conditions were so bad we decided to lay up under the shade of the wings for the rest of the day and go on early next morning. We learned afterward that the place where we had landed rejoices in the name of Warlock Ponds, and I am never likely to forget it as long as I live.

As soon as the sun went down a solitary mosquito came buzzing around our little camp and presently selected Shiers as his victim. Finding him good, the mosquito, being a sportsman, did not wait until he had had his fill, but buzzed off back to his pals at the water hole and told them of his find. In a few minutes the air was thick with them and I have never known insects so venomous. Sleep was impossible and the only way we could rest was by wrapping ourselves completely in a blanket, but it was too hot to do this for long. We tried grass fires, a petrol fire, and everything else that we could think of, but all to no avail, and soon our faces, arms, and legs were just a mass of lumps.

About midnight I suddenly remembered that I had a bottle of very good Irish whisky in the machine that had been given me in London. It had not been opened and so at last I thought I had found something to keep these pests away. The whisky was divided into four portions and at once I proceeded to splash mine all over myself while the others watched the result. It was not long in coming. I am sure those mosquitos must have thought it was Christmas; they fairly swarmed around me and then kept coming back for another drink! To add to my discomfort, I was forced to watch Keith, Bennett and Shiers drink their portions while I vainly tried to lick up the drips that were running down my face.

It was after daylight before we managed to sleep and so our start was delayed until 10am. If anything, it was hotter than the preceding day and consequently the air was full of pockets and bumps and at times I had to work hard to keep the machine under control. We left the telegraph line at Newcastle Waters and turned off southeast.

About an hour later I was startled by a loud crack from the port propeller and was horrified to see that one blade had split from the tip to the boss. There was a tent pitched by the side of a track about a mile ahead, so I shut off both engines and came down and landed.

COBB'S CREEK

We calculated that we were about 20 miles from Anthony's Lagoon where there was a small police station and a petrol depot. At first it looked hopeless to think of repairing the propeller and going on, and so here we were marooned in a dry and desolate part of Australia, 150 miles [240km] from a telegraph and 450 miles [725km] from the nearest railway.

It was not a pleasing prospect by any means. Just after we landed, we were greatly astonished to see two motor cars coming toward us. It seemed too good to be true, as we thought that we would certainly have to walk the 20-odd miles to Anthony's Lagoon before we could hope for any assistance.

The cars contained Mr Sydney Peacock and his son, and Sergeant Stretton of the Mounted Police. Mr Peacock had been sinking a sub-artesian bore just where we landed and he was now going to remove his camp and travel back into Queensland until after the summer. Had we arrived an hour later he would have struck his camp, and we would have been faced with a long, hot, and dry walk.

We had little food and no water in the Vimy, but Mr Peacock kindly insisted on leaving us all his before he departed, and he arranged to have supplies sent out to us from Anthony's Lagoon. He also left us a sheet of galvanized iron with which Bennett said he could mend the broken propeller. We were camped there for three and a half days, during which time Sergeant Bennett carried out a wonderful, and what I consider, a unique piece of skilful workmanship. When the propeller blade had split in the air several splinters of wood had flown off, but Bennett, nothing daunted, shaped new bits out of a piece of packing case to fill the gaps. He next glued the split portions together, then cut the sheet of galvanized iron into strips and bound them round the blade. The strips of iron were fastened onto the blade with screws which we had taken out of the floorboards of the machine. When this was done the whole blade was covered with fabric and painted. So there would be little or no vibration the opposite blade of the propeller had to be treated in exactly the same manner.

The conditions under which we worked were very trying and during the middle of the day it was impossible to do anything except lie in the shade of the wings and pant. The shade temperature underneath the wings was as high as 125° [52°C] and the heat even melted our "Triplex" goggles and windscreens.

Water was very scarce and none of us washed for the whole three and a half

Keith Smith took this photo of the serendipitous 'rescue party' at Cobb's Creek, 14 December 1919.

days. The bore which Mr Peacock had put down contained semi-brackish water and we had to haul it up 150 feet [45m] in a small bucket. It was very dirty too as the bore had not been cleaned out since it was made, and the water made all of us ill when we drank it.

During the day we wore no clothes except our overalls and boots, but we were really quite happy by ourselves with no one to worry us and ask the same old innumerable questions about the speed of the machine, its weight, where we sat and so forth; it was the first real rest that we had had.

Keith amused me very much one evening. We were having our usual meal of tinned meat and biscuits when he suddenly remarked: "If we had some ham, we would have some ham and eggs, if we had some eggs". I believe it is a very old joke, but I had never heard it before and it sounded so very funny away out there, and I remember laughing about it for a long while afterward.

During the second night we were camped here, a heavy thunderstorm passed over and we managed to collect quite a lot of water as it ran off the planes [wings].

It was a great relief when the propeller was finally fitted on the engine again, and so well had Bennett done his work that there was practically no vibration when the engine was running.

From Anthony's Lagoon much of the flight over featureless country would have been drear and monotonous, but it was Australia and that was compensation enough. Moreover, we had the occasional diversion of passing over small outback towns, where many of the inhabitants rushed into the streets and stood looking up, waving and cheering, and wherever we landed there was always a warm welcome awaiting us.

Editor's note: The route continued through Avon Downs and across the Queensland border to Cloncurry, Longreach and Charleville. Smith's account fails to mention that during the climb away from Charleville, as Shiers recounted, there was "a terrific bang, and a flash of fire came out past Benny and me, and we wondered, and thought we were gone. Next thing we saw Ross juggling with the throttles. He switched off the port engine and down she went into the deck, and there we landed just outside Charleville". A piston con-rod in the Rolls Royce V-8 had broken off and punched through the cowling.

Unlike the propeller, the engine could not be repaired with ingenuity alone. A precision metal workshop was needed. Smith telegrammed NSW Premier Holman in Sydney with news of their "slight accident", later cabling that they would finish the journey by rail. But perseverance prevailed. The damaged engine and propeller were sent by rail 600km east to the railway workshops at Ipswich, where the engine was rebuilt and a new propeller made. It delayed their journey by seven weeks.

BELOW The rebuilt engine and new propeller on a test frame.

The crew with Sydney Peacock and the police sergeant.

CHARLEVILLE TO ADELAIDE

At Charleville we were joined by my old friend, Captain Frank Hurley, of Antarctic fame; he completed the rest of the flight with us in the Vimy, taking films and photographs, and his cheery optimism and unfailing good humour made us all wish that he had been with us the whole way from England.

The sublimest spectacle of the entire flight from Hounslow to our journey's end was to burst upon us when we arrived over Sydney and its wonderful harbor. Like a mighty fern leaf, ramifying and studded with islets, this glorious waterway unfolded below. The city and its environs, massed along the water-front and extending into the hinterlands, flanked by the Blue Mountains, compose a spectacle of exquisite charm and beauty. We headed up the coast and, turning through the entrance, entered the port.

Planing down to 600 feet [180m], we flew above myriad ferry-boats and vessels, from the whistles of which little white jets of steam spurted up, screaming a welcome; then across the rooftops, where crowded waving and cheering humanity, and over the streets below, where little specks paused to look up and join in the greeting. It was a great day — a time that comes once in a lifetime.

Not the least pleasant incident upon our arrival finally in Melbourne was the paying over of the £10,000

ABOVE Coming in to Sydney, 14 February 1920.

LEFT Captain Frank Hurley, with whom Smith had flown in No.1 Sqn in 1918, poses with his movie camera while the crewmen refuel and maintain the Vimy.

BELOW Arriving in Sydney, the Vimy taxies in on Nigel Love's new airfield at Mascot (now Kingsford Smith International Airport), 11:12am on 14 February 1920. Minutes later the aircraft was engulfed in a "great surging sea of humanity" as spectators rushed in.

The DH.9 after one of its many crashes, Moulmein, Burma, April 1920.

LATE STARTERS IN THE RACE

Having secured a financial backer in Scotch whisky bottler Peter Dawson (hence the letters PD adorning their aircraft), former flying corps officers Ray Parer and John McIntosh left London's Hounslow airfield in a single-engined DH.9 bomber on 8 January, 1920. The fact Smith's crew had won the race a month earlier did not deter them.

Parer and McIntosh's odyssey was even more fraught and protracted than the Vimy crew's. Forced landings along the route caused delays. The DH.9's problematic Siddeley Puma engine was prone to misfiring and even caught fire. A downdraught over Italy's Mount Vesuvius almost spelt disaster. Stranded in the Syrian desert, the pair were attacked by Arabs. At Moulmein in Burma, a crash landing on the crowded racecourse smashed the undercarriage and radiator. The exhausted duo reached Darwin on 2 August after a 208 day journey.

When they finally arrived in Melbourne (without their aircraft, which had flipped over on landing at Culcairn, NSW) they presented Prime Minister Billy Hughes with a bottle of Dawson's whisky. Hughes reciprocated with a consolation prize: £500 and an Air Force Cross for each.

Today, their "old bus" is displayed at the Australian War Memorial.

prize by the Prime Minister, the Right Hon. W. M. Hughes, on behalf of the Commonwealth Government. As all participated equally in the perils and labours of the enterprise, the prize was divided into four equal shares.

In Melbourne I formally handed the Vimy over to the Commonwealth Government on behalf of Messrs Vickers, Ltd, who generously presented the machine to the Commonwealth as an historic relic of the first aerial flight from London to Australia. At the request of the authorities, I flew the machine on to Adelaide, my native city, and thus realised to the full my ambition and dream of flying from London to my own home.

It would be hard indeed to comprehend the feelings that surged through me as I landed the Vimy on the sod of my native city — the recognition of familiar faces; the greeting of well-known voices; the hand-clasp of innumerable friends; but, greatest of all, the reunion with my parents after five long years.

Our heartfelt thanks are due to the officers and mechanics of the Royal Air Force; to the Dutch authorities for constructing aerodromes and other assistance, and for the co-operation of numerous friends, whose willing and generous help laid the paving stones over which Fortune piloted me.

My brother Keith shares equally any worthiness that the effort might merit, as also do my two master mechanics, Sergeants Bennett and Shiers, whose loyalty and devotion to duty have done much to bind closer the outposts of the Empire through the trails of the skies.

BELOW Prime Minister Billy Hughes hands the £10,000 cheque to Smith in Melbourne, 27 February 1920.

POSTSCRIPT

Sir Ross Smith, already a household name, was now the world's most celebrated aviator. After reaching Adelaide on 23 March 1920 he flew the Vimy back to Melbourne. There it joined a museum display at the Exhibition Building, where it sat among 23 Australian and German warplanes. Jim Bennet was invited to speak of his experiences to groups of school children, firing their imagination as they gazed upon what was at the time the largest aircraft ever seen in Australia.

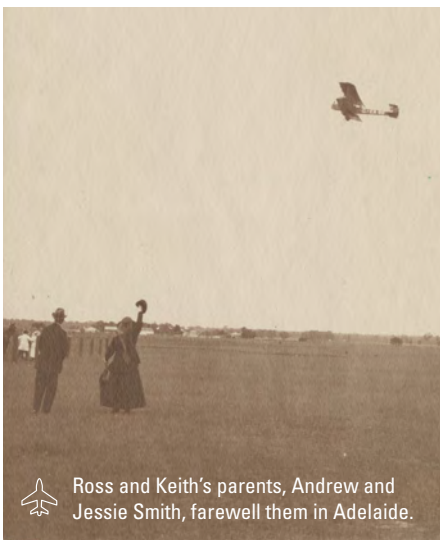
Young Geraldine Peters penned her thoughts in a contemporary school essay competition: *As we look at it, we picture in our mind's eye its journey. We think of all the weather it has gone through – sometimes terrible snowstorms, blinding, cutting hail, and then perhaps it will pass into the torrid zone and fly under a blazing sun. It has seen the battlefields of France, the burning sands of Indian deserts, the old historical Holy Land, and sometimes for hours nothing but a wide expanse of the sea. But through all these it brought its passengers home to safety.*

LEFT At Northfield, 15km north-east of present-day Adelaide Airport, thousands welcome the airmen to their home city.

BELOW LEFT Welcome luncheon for the crew in Adelaide's Queen's Hall, 25 March 1920. Ladies gathered in the gallery.

For two of the crew, safety was not long lasting. In 1922, while in England preparing for a round-the-world flight, Ross Smith and Jim Bennett died in the crash of a Vickers Viking amphibian aircraft.

By then the venerable Vimy's original British serial number, F8630, had been changed to RAAF serial A5-1. However, the RAAF had no use for the well-worn aircraft. From 1941 to 1955 it was displayed at the Australian War Memorial in Canberra, before being trucked to Adelaide Airport for display in a purpose-built building. A fire in transit destroyed its wings, which had to be remade. A century after the historic flight it is fortunate that we can still gaze upon this, one of Australia's – and the world's – most significant aircraft.



Ross and Keith's parents, Andrew and Jessie Smith, farewell them in Adelaide.

ABOVE Smith brings the Vimy in to Adelaide, 23 March 1920.

ABOVE RIGHT Harry Leckie mounts an aerial camera on a No.1 Sqn BE.2e. Photo courtesy AWM.

BIRTH OF THE RAAF ASSOCIATION

Private Harry Leckie was one of the first photographers to serve with Ross Smith's No.1 Sqn, Australian Flying Corps (AFC), in the Middle East in 1916. He was back home in Geelong, Victoria, when the Vimy made its way south from Darwin. Leckie felt that the crew's wartime comrades should get together to welcome them when they reached Melbourne. It might also be the start of an association for former AFC men.

He put an ad in the newspaper asking former members to meet outside St Paul's Cathedral. Among the many who showed up was former No.1 Sqn commander 'Dicky' Williams, future 'Father of the RAAF'.

The night after the crew reached Melbourne on 25 February 1920, an informal welcome dinner was hosted by No.1 Sqn at Scott's Hotel. Guests included Smith's fellow officers in the Sinai-Palestine campaign, Lt Gen Sir Harry Chauvel and Capt Frank McNamara VC. There it was agreed to form an Australian Flying Corps Association in Victoria, and in a year the idea had spread to other states. Twenty years later the AFC Association became the RAAF Association.

Leckie left another legacy. His wartime memoirs are held in the collection of the Australian War Memorial, providing a rare insight into how the squadron's photographic section did its job. Its production of aerial photographs for the all-important reconnaissance maps of the region was second to none. For its work his small band was commended by British high command.

ABOVE EFC Schools Competition Flyer

BELOW On 20 October, members of the public could walk around the aircraft during a special Vimy Open Day at Adelaide Airport.

BOTTOM EFC Committee leadership team, from left: Greg Mackie (chair); Lainie Anderson (EFC ambassador); GPCAPT Greg Weller (deputy chair); Dr Andy Thomas (EFC patron).

A Dragon, two Chipmunks and two Tiger Moths conduct a special flypast of the Vickers Vimy Memorial, Adelaide Airport.

CENTENARY RE-ENACTMENTS

To mark the centenary, three re-enactment flights have been arranged. Last November-December adventurer Michael Smith flew out from England in a Sea Bear amphibious aircraft named *Southern Sun* (see southernsun.voyage/currentadventure). During 8-23 March he will join others for a flight from Darwin to Adelaide, timed to end on the centenary of the Vimy's arrival there. Last November, Smith's friend Stefan Drury (stef747.com), flying a Cirrus SR22 G3 composite, followed the survey route from Melbourne to Darwin made by Wrigley and Murphy's BE.2e.

Adelaide also hosted a packed calendar of events to mark the Epic Flight Centenary.

Photos GPCPT Greg Weller.

The Sea Bear (left) and Cirrus. Photo courtesy Stefan Drury.

A GROWING DISPLAY

WORDS Mike Milln

ESTABLISHED BY A GROUP OF ENTHUSIASTS, THE SOUTH AUSTRALIAN AVIATION MUSEUM COLLECTIONS HAS GROWN INTO ONE OF AUSTRALIA'S BEST.

IN 1984 A GROUP of aviation history and restoration enthusiasts met in a pub and formed the South Australian Aviation and Warbirds Restoration Group. That initial name, incorporated in August 1984, gives a fair inkling of what the aspirations of the group were.

It leased premises at Glenelg to house its sole aircraft, an Avro Anson, and stayed there for two years while its horizons gradually broadened. The group became The South Australian Historical Aviation Museum the following year, and soon became The South Australian Aviation Museum Inc.

In 1986, the Glenelg site was to be redeveloped and the fledgling museum had to move. After a frantic search, a lease was secured on the old, dirty and pigeon infested SA Lion Flour Mill in Port Adelaide, and the museum's long association with Port Adelaide began.

By then, although the museum's collection policy was still largely based on expediency and member interests, it was evolving into its present focus, reflected in the museum's mission statement, "to promote the awareness, understanding and enjoyment of the past, present and future of South Australian aviation achievements and the role of aviation in the development and life of South Australia". The emphasis on South Australian provenance remains, although there is a parallel objective to accommodate items and educational displays of wider Australian aviation themes "deemed of substantial aviation interest to the public".

In January 1996 another move was necessary. Fortunately, an ex-RAAF Royal Navy-designed Pentad hangar being used as a wool store on the Port Adelaide docks became available. The hangar had been relocated after WWII from Darwin, where it had housed Spitfires. After the move, the museum's collection was revitalised by adding a mezzanine gallery and video displays, and by allowing entry to some aircraft.

Today, the museum remains an entirely volunteer organisation, funded almost entirely through its visitor and special events revenues, supplemented by some minor grants and generous private donors.

Hangar 2 panorama. Photo by Mike Milln.

BELOW Aerial view of the museum complex in September 2018 . Photo by G.Hartas.

Reception and shop. Photo by Lyle Whyatt.

Arrival of the Mirage in 2008. Photo by Mike Milln.

TRANSFORMATIONAL EVENTS

Several events helped the museum become one of the foremost aviation museums in the country, attracting 25,000 visitors annually. The first was in 2000 with its accreditation by the History Trust of South Australia to the National Standards for Museums and Galleries.

Accreditation required an explicit commitment to document and monitor its governance: collection management and preservation policy, proper financial management, occupational health and safety, ethics, disaster planning, strategic planning and so on. Among other things, that standard gives donors an assurance that any item donated cannot be disposed of without stringent procedures being followed.

Next came the building of the museum's current premises in Port Adelaide's Lipson Street Museums Precinct, a fortunate consequence of the 2004 Port River bridges project. The museum's then premises on Ocean Steamers Road were under the footprint of the new bridges. The new complex, on a state government 'peppercorn' ground lease, was funded by the federal and SA governments. Relocation required dismantling, refurbishment and re-erection of the historic Pentad hangar and the building of a new restoration hangar, reception hall and boardroom. The new premises were officially opened on 20 May 2006.

Since then the premises have undergone continuous development. A library and administration annex were added in 2011. A ground lease extension was agreed in 2014, allowing construction of a new 1,200sq.m display hangar opened in August 2017, co-funded by the museum and the federal government (the only significant grant funding received to date). External improvements have included secure storage compounds to accommodate containers and a storage shed, and to provide outside space for public events.

The third transformational event was the Air Force's formation of its History and Heritage Branch, which has a policy to make ex-Defence aircraft available at affordable cost to qualifying museums.

Under that policy the museum has acquired a DHC-4 Caribou transport, AP-3C Orion maritime surveillance aircraft and Kiowa helicopter.

A RF-111C (A9-134) was displayed on long-term loan from 2013 until April 2019 when it was exchanged for a F-111C (A8-132) which had been flown by the Aircraft Research and Development Unit (ARDU) and was moved from RAAF Base Edinburgh. The last remaining F-111 with operational provenance, '134' was transferred to the Australian War Memorial (AWM).

RAAF Reservists disassembled, transported and reassembled the aircraft, and the presence of an F-111 in the museum started a still-growing rise in visitation figures.

STRONG RELATIONSHIPS

The F-111 arrangement greatly enhanced the museum's relationship with the AWM, Air Force History and Heritage Branch, and RAAF Base Edinburgh. The acquisition of the AP-3C and a Mirage IIID from Edinburgh provided further opportunities to enhance the RAAF relationship, and to display the work of ARDU and the Edinburgh-based maritime squadrons.

The museum played a significant role in the celebrations for the centenary of the first flight from England to Australia in Vickers Vimy G-EAOU. Three of the Vimy's four crewmen were South Australian, and the aircraft is displayed at Adelaide Airport. For the Epic Flight Centenary celebrations the museum produced a life-sized mural on its Pentad Hangar doors, depicting the Vimy in flight.

The museum's relationship with the wider historical community has been enhanced, including with the History Trust of South Australia, RAAF Association (SA Division), RAAF Edinburgh, the State Library of South Australia, and the many other stakeholders on the History Trust's Epic Flight Centenary Committee.

The museum contributed many Vimy artefacts to the State Library's 'Heroes of the Sky' exhibition. It also provides displays to RAAFA (SA) for commemorative events and, recently, to the RAAF for its Edinburgh Air Show.

In 2018 the museum's aviation history research group worked to identify WWI airmen who were missing from the roll of honour at Adelaide's National War Memorial. As the names were added to the roll, a whole new range of relationships were formed with Veterans SA and other state government agencies.

RIGHT The F-111 exchange, 18 May 2019. Photo by Phil Hosking.

THE COLLECTION

The collection consists of 27 displayed aircraft and several more under restoration or in storage, as well as engines, propellers and 26 interpretive displays of historic aviation artefacts.

AIRCRAFT ON DISPLAY

- Aero Commander 680 (VH-PSG)
- Aermacchi MB-326H / CAC CA-30 (A7-026)
- BAe146-300 (VH-NJL) - cockpit and fuselage section only
- Bell 206B-1/OH-58A Kiowa (A17-010)
- Blue Steel Missile
- Cessna CC-1 (1986 replica of Clyde Cessna's 1911 design)
- Dassault / GAF Mirage IIID (A3-115)
- de Havilland DH-60G Gipsy Moth (VH-ULJ)
- de Havilland DH-100 Vampire FB.31 (A79-202)
- de Havilland DH-112 Sea Venom (WZ931)
- de Havilland Canada DHC-4 Caribou (A4-225)
- Douglas C47B-35-DK Dakota (A65-114)
- English Electric Canberra B2 (WK165)
- English Electric Canberra T4 (WD954) – cockpit only
- Fokker F27-109 Friendship (VH-CAT)
- Free Flight Twister 134 hang glider
- General Dynamics F-111C (A8-132)
- Gloster Meteor F8 (A77-851) – cockpit only
- Government Aircraft Factory Jindivik (N11-752)

ABOVE Interior of the BAe146. Photo by Lyle Whyatt.

- Government Aircraft Factory Ikara (TN304)
- Hall Cherokee II glider (VH-GPR)
- Lockheed AP-3C Orion (A9-756)
- Northrop Shelduck KD2-R5 (N10-53152)
- Piper PA-24/250 Comanche (VH-DOL)
- Sheppard CS-2
- Supermarine Spitfire Mk Vc (EE853)
- Van's Aircraft RV-4 (VH-NOJ)
- Westland Wessex HAS31B (N7-224)

UNDER RESTORATION

- Aero 145 (VH-WWC/ZCL)
- Avro Anson I (EF954)
- Fairey Battle I (N2188)

IN STORAGE

- Bedford Airport Fire Tender
- DH-60M Gipsy Moth (VH-ULO)
- Fokker Dr.I Triplane (scale replica)
- GAF N-22 Nomad (VH-SUP)
- Grunau IV glider prototype
- Hornet 130S flying wing
- Kavanagh D-77 hot air balloon (VH-HOV)
- Terrafly 10-0571 ultralight

In addition, the museum has some 35 historic engines and 29 free-standing propellers. The engines include a Gnome Monosoupape rotary, Armstrong Siddeley Lynx V and Cheetah IX, and Rolls Royce Kestrel and Merlin III which are operated during the museum's biannual open days.

Interpretive displays are located around the periphery of the Pentad hangar and on its mezzanine.

Themes include the first flight from England to Australia, the world wars, No.24 Sqn RAAF, Australian Women Pilots' Association, air traffic control, Qantas ground equipment, Guinea Airways, the Royal Aero Club of South Australia, and South Australia's famous aviators. Many of these include video material.

BELOW Hangar 1 panorama. Photo by Lyle Whyatt.

BELOW The new Vickers Vimy mural on Hangar 1. Photo by Lyle Whyatt.

BELOW The mezzanine displays in Hangar 1. Photo by Lyle Whyatt.

BELOW The ex-ARDU F-111 in Hangar 1, June 2019. Photo by Mike Milln.

FUTURE PLANS

To accommodate future aircraft acquisitions from Defence Disposals and private sources, the museum is seeking another ground lease extension to allow the option of building a third display hangar. Alternatives to this option include extending the restoration hangar to use its western end for displays. An engine workshop is being built adjacent to an existing storage shed, so that work on the engine collection can be moved out of the restoration hangar. Off-site storage options are being examined to allow the museum to continue its policy of not displaying any of its collection outside.

Upgrading existing displays will continue, with improved infrastructure such as glassed-in display bays, better protective fencing, and additional audio-visual hardware. An expanded aerospace display will be based on the existing 'Rockets in the Desert' Woomera display of loaned Woomera rocketry from Defence Science and Technology and interpretive material about the career of SA astronaut Andy Thomas.

Both display hangars are cooled by evaporative air-conditioning, and other public areas of the museum are fully air-conditioned.

• The museum is open every day except Christmas Day from 10.30am to 4.30pm. Phone 08 8240 1230 (opening hours only), email enquiries@saam.org.au.
For more information see saam.org.au.

AIR DEFENCE OF

WESTERN THAILAND

IN THE THIRD AND FINAL INSTALMENT OF THE UBON STORY, **BOB RICHARDSON AVM (RTD)** DESCRIBES THE "INCREDIBLY VALUABLE LIFE AND FLYING EXPERIENCE" HE GAINED DURING HIS FOUR DETACHMENTS FROM BUTTERWORTH TO 79 SQUADRON.

OUR FLYING OPERATIONS were similar to those carried out by the four other RAAF Sabre Squadrons of the 1960s: our primary role was air defence of western Thailand, using Sidewinder heat-seeking missiles that home on the target's hot engine exhaust, and two powerful Aden 30mm cannons. The guns were aided by a small ranging radar in the nose that adjusted the gun sight reticule for measured target range.

We spent a lot of time at air-air tactical intercept training under the control of the nearby USAF air defence radar, call sign 'Lion'. But its American controllers were primarily occupied in training Thai air defence controllers, whose skills were at that time very limited. Together with their language difficulties, that made Lion's assistance often haphazard, and all pilots quickly learned to keep a running mental plot of location, especially as two fairly unfriendly foreign borders were nearby. Communist Laos was the most

ABOVE The final 79 Squadron photo in Ubon, Thailand.

BELOW The USAF 'junkyard', where the casualties of war and other incidents were parked. The sign only lasted two days as USAF Base Commander Col Knutsen "was not amused".

unfriendly at that time, while Cambodia under its hereditary ruler, the mercurial Prince Sihanouk, was simply an unknown quantity we were supposed to avoid antagonising. However, it was common to accidentally stray into Cambodian airspace when operating above cloud due to confusion by Lion controllers.

We also practised simulated air-to-surface bombing, rocketry and gunnery attacks against Thai infrastructure such as bridges, trains, truck convoys, etc. Those 'strike sorties' could range almost all over Thailand when we carried the two larger 167-gallon fuel tanks and used high-altitude transits from and return to Ubon, usually with a 50nm high-speed concealment dash at 200 feet to and from the chosen target. Fuel was often critical on those long-range sorties, and with almost no diversion airfields available and inaccurate meteorological data when flight planning, rather nail-biting returns to Base with less than 5 minutes to fuel exhaustion were not uncommon.

In my later deployments after mid-1964 a full USAF Squadron of the remarkably capable F-4C Phantom fighter-bombers deployed to Ubon for operations over North Vietnam. The F-4C was a truly impressive state-of-the-art aircraft that was routinely tasked for 4-6 hour primarily bombing missions from Ubon, carrying three large external drop-tanks, two Sidewinder missiles, four beyond visual range, radar guided Sparrow missiles, a six-barrel 20mm Vulcan cannon firing at 6,000 rounds per minute and, normally for strike missions into North Vietnam, 10 x 750lb high-explosive bombs! Air refuelling from Boeing tankers continuously deployed over northern Thailand and also in international waters off the Vietnam coast, allowed tremendous flexibility for mission planning.

Typically, after bombing their primary target, the standard flight of four F-4s would loiter off the North Vietnam coast near to refuelling tankers and, under the control of USN radars, undertake attacks against enemy fighter aircraft. Then on the return to Thailand they sometimes conducted low-level ground target strafing before transiting Laos back to Ubon. Occasionally tropical thunderstorms over Ubon might close the airfield for a period, but the refuelling tankers readily permitted holding for the required period. On such occasions I recall seeing pairs of exhausted F-4 crews barely able to walk after unstrapping from their ejection seats. Operational sorties occasionally extended up to 10 hours when weather at Ubon required extra holding.

Overall, my eight months over four detachments from Butterworth to 79 Squadron provided incredibly valuable life and flying experience for a rather naive youngster, only a little over a year out of flying training school at Pearce. I suspect very few of my predecessors would have had that opportunity while so inexperienced.

After the USAF Phantoms arrived at Ubon, there was a good deal of interaction between the crews of 79SQN and the 45th Tactical Fighter Squadron. As most of the USAF crews had less than 100 hours on the F-4C, they were acutely aware that the development of tactics for their expected ACM (Air Combat Manoeuvre) engagements with MIG15s and 17s was lacking. FLTLT Mick Feiss (the 77SQN FCI) volunteered to give a briefing to the crews on the tactics

and close-in combat manoeuvres used by 79 Squadron with the Sabre. The logic was that the performance of their expected opponents over North Vietnam roughly equated to that of our Sabres. The offer was eagerly accepted and as usual, Mick covered the topic in exceptional detail. While the Phantom had a superb radar and the Sparrow beyond visual range missile, it also carried the AIM-9 (a more capable model than ours) and its use in the visual environment was at the forefront of all concerned.

Over the next few weeks, we flew several missions with them to allow the USAF guys to work up effective tactics using the enormous power and performance advantages of the Phantom. Their advantage in the vertical plane was soon apparent in combat manoeuvring and this was further developed between Mick Feiss and his counterpart in the 45th.

We soon scheduled a series of ACM engagements (4v4 and 2v4) on their return leg from strike missions up north. While ACM was probably the last thing on their minds after getting home unscathed, the benefits paid off in June 65 when the 45th achieved the first USAF kills of the war. As a matter of fact, the crews came over to our mess on the night of their return to celebrate. That interaction between the squadrons was given credit in the USAF records both then and later; the activity continuing with the 8th Tactical Fighter Wing Phantoms of Colonel Robin Olds and 'Chappie'James.

The pilots in 79SQN were all rather envious of the Phantom drivers doing their 'stuff' and we used to 'escort' some of them up to the Thai/Lao border (and beyond when unsure of the position!) on their way north. The short range of the Sabre without an air-to-air refuelling (AAR) capability was blindingly obvious compared to our new 'friends'. Just up from the 79SQN crew room was the USAF 'junkyard', where the casualties of war and other incidents were parked.

In the area were an RF-101 and an F-105D, both of which had received hits in NVN but struggled back to Ubon. There were also bits of other aircraft, including an AAR probe off an F-100 Super Sabre.

ABOVE A Sabre with an air-to-air refuelling "modification" – which was photographed and sent to Butterworth– with Bob Richardson standing in front to hide the rope attaching it.

RIGHT The Sabre wreckage.

BELOW RIGHT Campbell McFarlane at Wat Ban Phon Mueang with the souvenired nose wheel of his father's Sabre.

I had a bright idea and enlisted the help of another pilot. We 'borrowed' the AAR probe and bought it down to our lines. The CO 79SQN at the time had a cynical sense of humour so I outlined a 'plan' to fix one of our aircraft with an AAR mod, take a photo of it and send it back to Butterworth saying we had installed a modification on the fuel system to enable us to do some AAR trials with the USAF. We tied the rear end of the probe to the port undercarriage leg with a heavy rope over the Sidewinder rail to hold the probe in the horizontal position, then I stood in front to hide it.

The picture (see above) looked reasonably realistic and we sent it down to 77SQN at Butterworth, with a thinly disguised explanation of our efforts to improve the operational capability of the Sabre. Squadron crews at Butterworth saw the joke right away but one of the techos at Ubon got a nasty message from 478 Maintenance Squadron, asking who had authorised the modification and didn't he know that such changes had to be approved by Support Command in Melbourne etc!
I guess there are always some who can't see the wood for the trees. Anyway, we all had a good laugh about the things boggies will get up to!

In September 1964, Don McFarlane, while on a training mission, had an engine failure west of Ubon. He tried to return to Ubon but ejected safely at 700ft and 135kt near a small village about 30nm west. He was rescued by a Royal Thai Air force helo.

As there was little recoverable wreckage, the RAAF donated it to the local village and we heard that the bigger remains were taken into the village as 'souvenirs'. The engine was retrieved about 12 months later for investigation and the failure was shown to be foreign object damage induced.

END NOTE:
Many decades later, Don McFarlane's son, Campbell, sought information regarding his father's ejection. He found the village, Ban Phon Mueang, but no one there could remember the accident although he was told about stories handed down from grandparents and the like who had mentioned a crash near the village a long time ago. As the RAAF recovered the engine about a year after the loss courtesy of an operation headed by Bruce Martin in an Iroquois, little else could be found near the local wat or elsewhere in the village. Someone said to try the school and, as the photograph above left indicates, he succeeded in finding positive proof. Determination paid off!

WITHDRAWAL FROM UBON

The last OC Ubon, WGCDR Peter Scully, describes the lead-up to 79 Squadron's withdrawal from Ubon on 26 July 1968.

I'd received a 'secret' message from Canberra ordering the aircraft to withdraw on a certain date. A few days later I and all the other Commanders were summoned to the Governor's residence to be told the King was to visit on a date just after our withdrawal and he directed each of us to undertake certain tasks relating to the visit; oh dear! So, I sought a private audience to break the news of our departure. His immediate reaction was a very sharp "Well, you won't go!". (Some may recall that the Governor pretended not to speak English and so always acted via an interpreter – his very pretty niece Wan Penh.) But on this occasion his English was prefect. So, I sent a message to Canberra explaining the situation and suggesting a later departure date. I received no reply so I promptly told them – acting like the perfect diplomat – that we were not leaving on their determined date. Still absolutely no response. Well, at least I then had the chance to shake hands with the King.

We then had to plan the withdrawal of our heavy equipment which had originally all been flown in. Butterworth directed a large road train. The local security folk advised that we'd be attacked and that we should provide armed protection for the convoy. Our Ambassador was horrified and directed no armed protection much to the horror of the locals (and us). The problem was solved, as we had no import licences the Thais would not grant export licences – so everything was then flown out.

There was also the problem of obtaining Thai export visas for the many airmen who'd married local women. The solution was to send the Padre (who later officiated at my own marriage) to Bangkok by train armed with a case of Johnny Walker Black Label. That did the trick and all the necessary permits were issued.

Our accountant officer advised that all the substantial sum in our Officers' Mess General Reserve account would go to the 'Disbanded Messes Fund' when we left. He suggested a great solution: we just held General Mess Meetings and transferred money from the General Reserve to the Entertainment Account which we then used to have several grand dining-in nights at a local restaurant. I remember the Service Police used to call by to drive my car – and me home.

Our MO, Dr Bill Knox, ran a very effective civil co-operation program, together with a couple of USAF officers. They would help themselves to the USAF supplies and go about repairing local temples and schools. So, the RAAF was able to maintain great respect within the local community. Indeed, at our farewell function, the Governor was present as he was a frequent guest and the USAF Base Commander approached me and said "What have you b…s got on that mo f…, every time I'm in your mess he's here too; I've invited him to our club many times but he's never once accepted."

I managed to snag two trips over Laos in target marking aircraft, one an O1 (Cessna O-1 Bird Dog), the other an O2 (Cessna O-2 Skymaster) – also a trip up north in an F-4, piloted by a Capt 'Wild Bill' Hickock of the 433rd TFS (he was in 'Up Tight D Flight' – some will remember their emblem). The trip was recce only and I was very surprised and pleased to be awarded an 'Hon. Life Time of the 8th Tactical Fighter Wing'.

The USAF Commander was very genuinely concerned about our leaving, particularly as the Chinese had recently moved IL28 light bombers (NATO code name Beagle) down to the North Vietnam border. The USAF then had to divert some of their strike force to air defence.

It was a very sad departure and I consider my great good fortune at being involved with such an efficient and greatly respected organisation.

A Handley Page Halifax bomber of No.466 Sqn RAAF at Leconfield, England. Frank Mack is the Officer in the foreground. Photo courtesy Australian War Memorial (SUK 12130).

WWII HALIFAX BOMBER

CREW REMEMBERED

IN 1944, HALIFAX HX233 OF NO.466 SQN RAAF WAS SHOT DOWN DURING AN AIR RAID OVER BERLIN. SIX CREWMEN DIED, INCLUDING PILOT FLTLT FRANK MACK. LAST YEAR, FLTLT MACK'S SON AND FAMILY TRAVELLED TO HIRSCHFELDE, GERMANY TO DEDICATE TWO PLAQUES IN THEIR HONOUR.

SEVENTY-FIVE YEARS SINCE the end of WWII, it is timely to reflect on the Australian contribution to RAF Bomber Command's campaign to cripple Nazi Germany's industry. Six RAAF squadrons flying Wellingtons, Lancasters and Halifaxes, as well as many Australians in RAF squadrons, took part. The German defences and other factors such as mechanical failures, weather and human error ensured that the cost to Britain and the dominion nations was high: 55,000 airmen died, including more than 4,000 Australians – a death rate of 40 per cent.

On the night of 28 January 1944, near the end of the three-month-long assault on the German capital known as the Battle of Berlin, a force of 677 bombers set out from England. This raid alone left some 180,000 Germans homeless, and 46 bombers did not return. Halifax HX233 of No.466 Sqn RAAF dropped its bombs and left the city to the north-east but was attacked by a night fighter. Its bomb aimer and navigator were able to bail out, but the aircraft exploded before the remaining six crewmen could escape.

Its pilot was 31-year old FLTLT Frank Mack of "Weemabah" near Trangie, NSW, whose widow Marion was informed two months later that he was presumed dead. It was another three years before RAAF enquiries brought to light any details. Marion Mack was told that outside the village of Hirschfelde, 30km north-east of Berlin, Luftwaffe personnel had recovered the six bodies from the wreckage and interred them with full military honours in the village cemetery. Five of the six were identified by their ID tags. The plots were well tended by the villagers until the remains were relocated to Berlin in May 1947. Marion was sent a photo of the new grave, as well as a scroll of commemoration, which she had framed for their two children.

In recent years, Frank and Marion's son George decided that his father's crew should be more fully commemorated. "Two years ago, it dawned on me that my father must have first been buried somewhere other than the British war cemetery in Berlin, as the bodies were not buried there until 1947. When I visited Hirschfelde two years ago, I was shown two burial plots for the six crew,

with a wooden cross on each inscribed 'Unknown soldiers were buried here'. As we knew who those airmen were, I thought we owed them a little more.

"In the village, I met Mathias Graf v. Schwerin, who said he would speak to the local minister and see if he would agree to putting a stone in the cemetery with a plaque. Mathias has been a great help, and without him I would never have got the project done. About a week later he emailed me to say some amateur fossickers had discovered some of the plane on his land. He asked if I would I care to put a plaque at the crash site as well."

Last year their efforts came to fruition and George and his family went to Germany to dedicate the two plaques. The Australian Embassy in Berlin sent the Defence Attaché. Others attending included Joan Dunn, a niece of HX233's second pilot FLTSGT Douglas Cowin RAAF, and Melvin Chambers of The Netherlands, who had recently organised the commemoration of Australian Dambuster pilot Les Knight. The daughter of wireless operator SGT "Jack" Barron RAF was contacted but was not able to attend. The other crewmen killed were FLTSGT David Alexander, SGT Harold Wright and FLTSGT Allen Morgan. The crew names with photographs can be found at the website 466and462squadrons.com.

ABOVE RIGHT The Mack family with the new plaque at the crash site. Photo courtesy George Mack

WILD BOAR, TAME BOAR

In July 1943, RAF Bomber Command introduced a simple but highly effective weapon against the ground radar that controlled the Luftwaffe's night fighter defences. This measure, codenamed Window, involved dropping foil strips into the air to produce confusing radar returns. But while Window did render the German radar-controlled 'box' defence system obsolete and saved many bomber crews, it paradoxically opened up another defensive tactic for the Luftwaffe, as Bomber Command historian Martin Middlebrook writes:

"There are many ex-Luftwaffe night-fighter aircrew who believe that Window was the finest gift that could have been given to the German defences. It forced the Germans to send their fighters 'freelancing' on the bomber routes into and away from the cities being attacked, each German crew using its own initiative to find the bombers."

Defending Berlin were both single-engined fighters (Wilde Sau or Wild Boar) and nearly 400 twin-engine fighters known as Zahme Sau (Tame Boar). The latter were directed to the bomber stream by radio from the ground and, once they reached it, new Window-penetrating airborne radar equipment allowed them to hone in on individual bombers.

ABOVE A Messerschmitt Bf 110G-4 night fighter equipped with Lichtenstein nose radar and twin 20mm cannon pod. Some also had schräge Musik upward-firing cannon

INVESTING

WITH A PURPOSE

CHOOSING THE RIGHT INVESTMENTS AND REACHING FINANCIAL GOALS IS A LOT EASIER WITH A ROADMAP.

MOST OF US DON'T normally get into our car with no idea where we are going, or the road we'll take to get there, and yet, many people take exactly that approach to investing. They head down the investing highway with no clear picture of why they are doing it or what they hope to achieve. Investing is not a destination, it's a path we take to reach a financial goal.

Why invest our money at all? Some would say the purpose of investing is to accumulate wealth, but to what end? How would it make your life any different? What are you going to do with this accumulated wealth? Are you building a property portfolio so you can retire early and travel the world? Have you started investing in shares so you can afford a good education for your children in the future?

If you know what the end goal is, you can put a timeframe on it and estimate how much it will cost. That is important because it helps you work out how much you'll need to save and what types of investments will be appropriate.

When you can answer the 'why' question, you have your purpose for investing. You can then start putting together an investment plan, your roadmap to reaching your financial goals.

DEVELOPING AN INVESTMENT PLAN

With a plethora of investment choices available, choosing the right one for you will depend on your investment plan.

Different types of investments are more suitable for shorter or longer-term goals. The investments you choose will need to be appropriate for your:

- **Investment goal –** what are you saving for?
- **Timeframe –** when do you want to reach the goal?
- **Current investments –** is it different from other assets in your portfolio, helping you lower your risk through diversification across different assets classes?
- **Tolerance for risk –** does it pass the 'sleep at night' test?

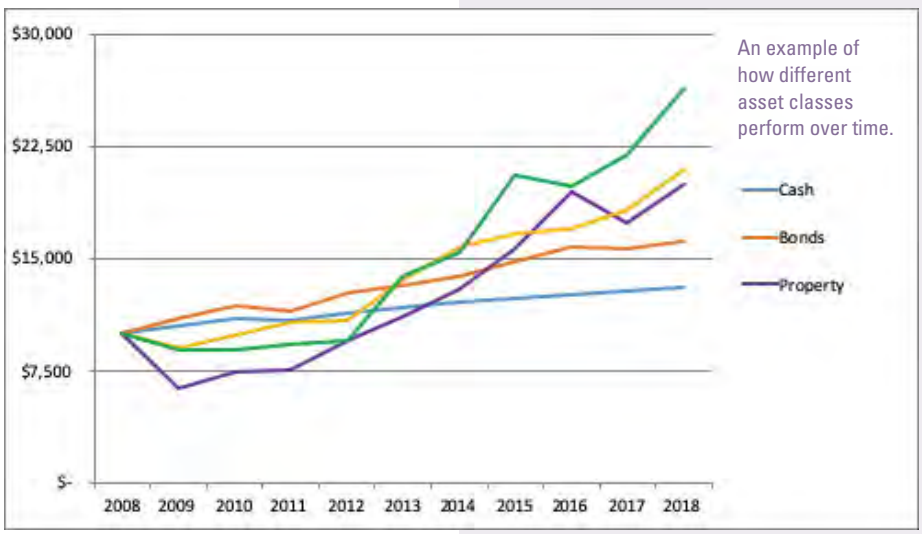
GOALS & TIMEFRAME

Setting a financial goal and a timeframe for achieving it is about stating what you want, when you want it and how much it's going to cost. Goals need to be realistic and achievable. If you set yourself a target of saving $500 a week but your current budget suggests that only $300 a week is realistic, then you're setting yourself up to fail. You may need to adjust your goal, the timeframe, or both. If a goal you set will take longer to achieve, it may allow you to choose from a wider variety of suitable investments because you have the time to ride out the short-term volatility of investment markets and achieve better long-term returns.

ABOVE An example of a savings goal.

DIVERSIFICATION

Diversification is about managing the risk/reward trade-off by selecting a mix of investments to help you achieve more consistent returns over time. Different investment markets peak at



An example of how different asset classes perform over time.

different times so limiting your exposure to a single asset class will reduce your risk of a large loss in any given year. So before you take on a new investment, consider what you already have and ask yourself whether the new investment will diversify your position and therefore lower your overall investment risk.

Assets that carry a higher risk usually deliver a higher return over the long run but are likely to have more volatile returns over the short term. You can offset some of that risk and volatility by including assets in your portfolio that have lower short-term volatility, lower risk, but also lower returns. As well as diversifying across asset classes, you could also consider diversifying within asset classes. For example, a share portfolio may include shares in companies from different industries such as mining, banking, consumer goods and healthcare. Or you might keep it simple and invest in a diversified share fund.

RISK TOLERANCE

In the long term, growth assets, like shares and property, will usually outperform an income asset, like cash, by a considerable amount. However, in the short term, growth asset markets can be quite volatile.

Your risk tolerance reflects your ability to cope with dips in the value of your investments. Any investment you make needs to pass the sleep-at-night test; if the risk worries you to the point of not being able to sleep, the investment is not for you.

Take the slower road but be calm when you arrive. Always choose investments you understand and are comfortable with, even if this means having to adjust your goals or the time it will take to achieve them. Keep in mind that dips in the market only represent a theoretical loss, until you sell an investment and crystallise the loss.

ABOVE Elements of an investment plan.

The same goes for increases in value, gains are not locked in until you sell the investment.

So before you head down the investing road, consider the factors that go into making a good investment decision; set a goal and a timeframe for achieving it, cost it out, consider how any new investment will complement your existing investments and think about whether you can tolerate market volatility.

• Nicole Hoschke, Financial Capability Educator, ADF Financial Services Consumer Centre

Affinity, an immersive, interactive light sculpture inspired by the complexity and connectivity of the human brain, at the winter lights festival, Canary Wharf, London, UK in January.

AFFINITY AND VALUES

THE OLDER YOU GET, THE MORE YOU REFLECT.

"WHETHER IT IS RESEARCH AND DEVELOPMENT, company management, or any other aspect of business, the active force is people. And people have their own will, their own mind, and their own way of thinking. If the employees themselves are not sufficiently motivated to challenge the goals of growth and development... there will simply be no growth, no gain in productivity, and no technological development unless it is introduced through a strategy of power and directives."

The above quote by Japanese entrepreneur Kazuo Inamori (quoted by Peter Senge in his book *The Fifth Discipline: The Art and Practice of the Learning Organization*) attracts my attention as to how to harness the "active force of people". I do see in my past an "active force of people". It was in the 1960s and 70s. The relationships were trusting, spontaneous, rewarding, motivating, inspiring and full of well thought out productivity. People rarely had to be taken to task for not doing their job: they wanted to.

I also learnt a lot about human dynamics while working with good leaders and working in good teams. That taught me much much more in the main than studying leadership books.

I moved on to new things in the 80s and 90s, never to again experience quite the same "active force of people". I consequently lost contact with most. I became so busy in my new enterprises that I never reflected sufficiently on those happy days of productivity.

And then in the 2000s, volunteering for positions in not-for-profits put me back in contact and lo and behold the relationships that I had abandoned up to 55 years ago were still as full on as they had been in the early days.

I took the re-establishment of that mateship for granted not questioning how it survived the years until one day one of my old mates became quite sick and his new wife, whom I had never met, accompanied him to a lunch. In a private moment she asked how long since I had seen her husband, which had been 48 years and she was astonished. She said the way you both greeted and the way you both spoke with such vigour, I thought indicated recent and ongoing friendship.

I walked away from that thinking that all my current relationships with old mates were like it was yesterday which was proven in many cases by the rapidity and strength that we got down to work together when our volunteer jobs crossed paths. And so, I started to reflect on that circumstance to see what messages could be gleaned from it.

Way back in the 60s and 70s, the jobs I worked were very demanding. Common experiences in demanding

circumstances can nurture relationships with your co-workers. However, I also remember there were people that I had demanding common experiences with who left me a little cold, still to this day. So it was not just the common experience.

I then looked again at the good people I valued and saw two other things besides our common experience; I saw affinity and values.

When I talk about values, I do not mean butter would not have melted in my coworker's mouths. They were larrikins on many occasions, irreverent and pains in the behind. But the values they practised never jeopardised the trust I had in them. The values they practised actually visibly defined the way they lived their life. Values can result in a feeling in another without a word spoken. Values can result is inspiration that makes you examine your behaviour. Values are not just words.

I saw in the 60s and 70s, that values meant you help your team members get it right or, together you look at ways to make things work. In my life were people that did not make negative assumptions about each other but did help each other succeed. I was with teams that looked upon each other positively while still taking the piss. I remember we maintained a positive mental attitude no matter what the circumstances.

I like to feel I am reasonable. I like to feel that I contribute. I like to achieve. I like to achieve things that make me proud. I like to be respected for who I am and what I offer. I like to think people will see my underlying value before I am judged. I am happy and positive. But then someone dumps in my space. Someone does something that is unreasonable in my book and leaves a bad smell. Next minute I feel indignant and hurt because they crossed some sort of imaginary line in my head. The other side of that same line is enemy territory. Bugger, my day is ruined. And then lo and behold, someone in my team walks up to me with a friendly disposition and my world is good again. What a prostitute I am.

> "Those who stand for nothing fall for anything." Alex Hamilton

My team member had affinity and changed my mind set.

I love people who just are, without any frills or decorations getting in the way. I love people who are confident but who are humble. I love all peoples who are like this no matter what their creed, colour, politics or religion. I feel comfortable with them because they have affinity.

The world can be the toughest place to live. The world can also be just plain glorious on some days. But some people just have affinity no matter what. They may be sad. They may be angry. They may be contemplative. They may be in a hurry. But all the time they have affinity.

Affinity is an acceptance of how the world is and how people are. Affinity is the foundation to counter the inevitable chaos of life. It is the hardest thing to have constantly. It is next to impossible for any relationship to be sustained without affinity. Look at its effects: it becomes the glue between us, it becomes the foundation of trust. It is the foundation of leadership. It is the foundation of comfort in relationships. It means I see you.

Affinity often has to be hard won while you battle through your own rejection of people and their provocative behaviour. But if you want to be happy, affinity for all people is the basis. To sustain affinity, you need to sustain a set of values. Values and affinity are peas in the same pod.

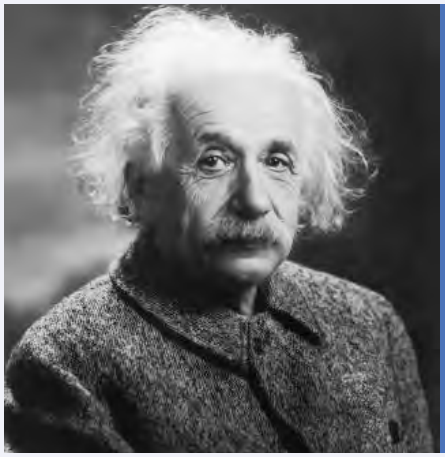
I found out and am still finding out that values are not a starting point they are an end point that is possibly never reached. Team values need to evolve and then to evolve again and again. But they only evolve through other people. So, the challenge is not just to practice values but to find out the dimensions of each, explore the boundaries and assess the universal quality of the values adopted.

The most effective teamwork and success in the most extreme physical effort happens when the inner space is strong. The inner space cannot be strong unless the outer space is in order for you. Team Values manifest themselves in creating a very supportive outer space.

A team value is keeping agreements but on occasions agreements get forgotten in the heat of the day because I am human and forget. Another team member, however, does not forget because it was very important to them and they become upset. Is being upset ok or should the other team value: "understanding that each other is human" take precedence. Now we have a clash of values.

Values have to live, grow and be interpreted all day everyday by everyone. W

• Shara Vewe, Team Consultant



> The most important decision we make is whether we believe in a friendly or a hostile universe."
>
> Albert Einstein

GENERATIONS OF
MILITARY SERVICE

LAST DECEMBER, Air Force Cadets from Adelaide's northern squadrons undertook Cadet Air Experience flights.

Among them was Cadet Marcus Dhillon from No.604 Squadron, Hampstead Barracks, who flew a Cessna Skyhawk C172 as part of his long-time aspiration to become a professional pilot. "My keenness to join the Air Force and become a pilot began when I was much younger and a commercial pilot showed me the controls in the cockpit of his aircraft," said Marcus.

Military service is in his blood; he is the fourth generation in his family to serve in uniform. His father, Barry, served as a Major in the Maratha Light Infantry 1997-2005. The regiment is the Indian Army's most decorated and most senior light infantry regiment, with its lineage dating to the Bombay Sepoys raised in 1768. Major Dhillon primarily served with 16 Battalion, but was also attached to 12 Battalion in 2001 as part of the first contingent to the UN Mission in Ethiopia and Eritrea.

Major Dhillon had followed in the footsteps of his own father, Balli Dhillon, who served in the Indian Army from 1966, including as Commanding Officer of 16 Battalion, Maratha Light Infantry. Major-General Balli Dhillon retired in 2004 as General Officer Commanding 11 Infantry Division. He is a recipient of the Vishisht Seva Medal, awarded to Indian Armed Forces members to recognise distinguished service of a high order.

With generations of martial tradition behind him, Cadet Marcus Dhillon now looks to a uniformed career in aviation.

"Through Air Force Cadets, I have been able to fly in a glider and experience pure flight, and have also flown in a light powered aircraft. And it was brilliant that this was witnessed by my grandfather, Major-General Balli Dhillon, who was visiting us from India," said Marcus.

Flying opportunities provided by Aviation Operations Wing inspire Cadets like Marcus Dhillon to achieve their dream.

BELOW Cadet Marcus Dhillon prepares for a flight in a Cessna Skyhawk C172, encouraged by his father (right), Major Barry Dhillon and grandfather, Major-General Balli Dhillon VSM.

FIRST SOLO
GLIDER FLIGHT

CHRISTMAS CAME EARLY for Cadet Under Officer (CUO) Alex Fogale when he graduated as one of the Australian Air Force Cadets' newest solo pilots in the DG1000S soaring sailplane, at Warwick Airport, Qld.

"My first experience in gliding was at Charters Towers in 2017," said CUO Fogale, who parades at No.106 Squadron (Tablelands) in Mareeba, North Queensland.

"Flying in silence is an unreal experience. Gaining height in a strong thermal is a great feeling. Knowing you are not using an engine to gain height gives you a great adrenaline rush.

"I will never forget my first solo flying experience. Knowing you are high in the sky by yourself with no instructor is exhilarating. Just before take-off, I had to check there was no flying instructor in the rear seat, to confirm it was really happening.

"Air Force Cadets will let you do a whole load of things if you put in the effort."

The December gliding course was attended by 25 Cadets from No.1 Wing (North Queensland), No.2 Wing (Southern Queensland) and No.8 Wing (Northern Territory).

"The Cadets were a mix of ab-initio students undergoing flying training for the first time, and more experienced Cadet trainees returning to further develop their skills," said Pilot Officer (AAFC) Brie Russell, Commanding Officer of No 902 Aviation Training

LEFT Following his first solo glider flight, CUO Alex Fogale is congratulated by flying instructor Flight-Sergeant (AAFC) Denis Lambert of No 902 Aviation Training Squadron.

Squadron at Warwick Airport.

The Squadron is one of three centres of excellence in Australia providing glider training for Air Force Cadets, with the intention of seeing them fly solo soon after turning age 15.

CUO Fogale completed the Silver Award of the Duke of Edinburgh's International Awards at the end of 2018, and was awarded an Officer Commanding No.1 Wing Commendation for his work during 2019. He has also received a 2019 Australian Defence Force Long Tan Youth Leadership & Teamwork Award from his school.

During 2019, he served as Chief Instructor for his Squadron. Having turned 18, he has now aged out of the Air Force Cadets but aims to rejoin as an adult instructor as soon as possible.

DIAMOND SOLO FLIGHTS

CADET CORPORAL JESSICA SCOTT from No.623 Squadron (Mildura, Vic) was one of nine Air Force Cadets to achieve solo flying status in the Diamond DA40 NG aircraft during a powered flying course run by the AAFC Elementary Flying Training School, late last year.

"My first training flight in the Diamond DA40 was amazing," said Jessica. "I had never been in an aircraft with such modern technology. When I took the controls for the first time, my heart was pounding and I was so scared I would mess it up.

ABOVE Following her first solo flight, Cadet Corporal Jessica Scott is congratulated by her instructor, Squadron Leader Gary Presneill.

LEFT Cadet Sergeant Archie Gaffney is congratulated by Squadron Leader Gary Presneill.

"Until then, the thought of going solo terrified me because there would be no instructor in the plane with you to help if you made a mistake. However, when I actually went solo, I didn't feel terrified. In fact, I felt so excited. It was definitely strange though, being by yourself in the plane for the first time.

"Cadets has taught me it is possible to achieve your dreams, even if they may seem out of reach at the time. It has also taught me to always have confidence in yourself and that if you put your mind to it, you can achieve most things."

During WW2, three of Jessica's great-grandparents served in the RAAF. Her maternal great-grandmother was an Aircraftwoman flight mechanic and her husband a Leading Aircraftman instrument repairer. And her paternal great-grandfather was a Flying Officer and air gunner in a Catalina, before later becoming a pilot. After WW2, he piloted an altitude test in a Liberator bomber over Melbourne, taking 90 minutes to reach a height of 32,000 feet (almost 10km).

Late last year, Air Force Cadet Sergeant Archie Gaffney from No.402 Squadron (Watsonia, Vic) also trained and then flew his first solo flight in the Diamond DA40 NG.

"It was slightly overwhelming with everything that was in the cockpit, but it very quickly became familiar," said CSGT Gaffney

"When my instructor, Head of Flying Operations - Squadron Leader Gary Presneill, got out of the plane before letting me take my first solo flight, it felt a bit weird and I was somewhat nervous. But after starting all my checks, everything became routine and it was all good after that."

In his parent Squadron, CSGT Gaffney is flight commander for Hornet Flight, holds the Individual Proficiency Badge, and is a Bronze Award participant in the Duke of Edinburgh's International Award. He proudly wears the Australian Air Force Cadets uniform to honour the Great War service of his great-great-uncle, Lance-Corporal Amos Turner, who deployed to France during WWI and was awarded the Military Medal for bravery while serving with 53rd Australian Infantry Battalion.

During WWII, the RAAF established 12 Elementary Flying Training Schools to meet the rapid demand for pilots in an expanding wartime Air Force. Some seven decades later, the Elementary Flying Training School has again been established – operated at RAAF Point Cook by the Australian Air Force Cadets and supported by Air Force.

PEARL HARBOUR PARADE

AT THE END OF LAST YEAR, the Riverwood Squadron of the Australian Air League (AAL) was invited to travel to Hawaii to perform in the annual Pearl Harbour Memorial Parade. Each year, one international band is invited to attend, and the Riverwood Squadron Marching Band is the first Australian Band to be so invited.

The Squadron performed alongside the battleship USS Missouri and with the Pearl Harbour Memorial Parade through the main streets of Honolulu. Parade participants included several surviving veterans of the attack on Pearl Harbour.

"It was an honour and privilege to be involved in this historic event. We performed the US Armed Forces Medley with the US Marine Corps Band and had just over two months to learn this completely new piece of music," Squadron Officer Commanding Chris Bailey said.

"I am so very proud of these Cadets as this was not easy to achieve as we were juggling our regular community engagements as well as training for our Hawaii performances.

"We would like to thank Ambassador Jane Hardy, the Australian Consul General in Hawaii, who took the time to meet with the Cadets prior to the opening ceremony."

Following their parade commitments, the cadets had the opportunity to take part in a three-day education program at the Pearl Harbour Aviation Museum. The museum displays 43 aircraft, from a Boeing Stearman Model 75 flown by former President George Bush on his first solo, to a retired RAAF F-111C.

"Seeing all the aircraft and learning about the history was amazing," said Leading Cadet Trystan Farah.

Activities included educational workshops, team building and leadership activities and they even got to sleep on board the battleship USS Missouri. Commissioned in 1944, the Iowa-class battleship is best remembered as the site for the surrender of the Empire of Japan, which saw the end of World War II, and after being re-activated in 1984 she provided fire support during Operation Desert Storm in 1991 before being permanently decommissioned.

"The Cadets can now take skills learned on the course and further develop them within our own communities at home," Squadron OC Bailey said.

This amazing opportunity would not have been possible without the continued support of the community including ClubRivers, Canterbury Bankstown Chamber of Commerce, Canterbury Bankstown and Georges River Councils, Lions Club of Lugarno and Oatley, Rotary Club of Hurstville, Bankstown City Unity Bank, various RSL Sub-Branches and many others.

ABOVE Cadets of the Riverwood Squadron band of the Australian Air League performing in front of the battleship USS Missouri.

ABOUT THE AUSTRALIAN AIR LEAGUE

The Australian Air League is a youth group for boys and girls aged eight years and older who have an interest in aviation either as a career or as a hobby. In the Air League they learn about aviation in all its forms through classes in theory of flight, navigation, aircraft engines and a variety of interesting subjects. It also aims to enable them to achieve their full potential and become better citizens.
With Squadrons in most states of Australia, the Air League has been serving the community in Australia since 1934. It is self-funding and staffed by volunteers.
For further information: phone 1800 502 175; email info@airleague.com.au; website airleague.com.au.

SERVING THE COMMUNITY

BUSHFIRES HAVE A PROFOUND impact on the communities living in the Southern Highlands and many of the Officers and parents of the Australian Air League Southern Highlands Squadron are also members of the local Rural Fire Service (RFS). Many were out battling the fires while their own homes were under threat. Those volunteers put their own safety at risk for others every time they are called out and many were battling the fires for weeks.

One of the core aims of the AAL, promoting good citizenship and community service is actively encouraged with cadets recognised for their effort through a series of Community Awareness Awards. The Officers and parents at Southern Highlands encourage cadets to get involved with the RFS.

Another Air League Officer who has been active in fighting the recent bushfires is 19-year-old 2nd Officer Daniel Oliver of South Australia Group. Daniel joined the Air League as an 11-year-old cadet and is now a Squadron Officer with Port Adelaide Squadron. He has been volunteering with the Country Fire Service at Athelstone and Yankalilla for four years and provided support to water bombing aircraft at the recent Cuddle Creek fire.

TOP Daniel assists with support for water bombing aircraft with the Country Fire Service.

LEFT Lt Comr Martin Ball presents 2nd Off Daniel Oliver with his officer warrant.

Productivity Commission REPORT CONCERNS

Carl Schiller, OAM, CSM National President

THE ASSOCIATION'S MAJOR CONCERN is for veterans' advocacy. The Productivity Commission proposes advocacy be provided by a statutory body with an outsourcing capability and in the meantime, while the statutory organisation is being created, by the Department of Veterans' Affairs (DVA). It has dismissed the recommendation from the Alliance of Defence Service Organisations (ADSO), which was a build on Robert Cornall's suggestion to create an independent organisation to provide a national advocacy capability and other support services to the veteran community.

The concept model proposed by ADSO was developed from an Air Force Association NSW Division project, chaired by President Ron Glew, for a national advocacy and family support capability. The proposed organisation would be a company limited by guarantee and be supported and managed by a Board comprising representatives of collaborating Ex-Service Organisations (ESO). ADSO was deeply concerned that if Robert Cornall's recommendations were not maximised, current and future generations of veterans would be supported by a sub-optimal system.

The Productivity Commission viewed the charitable and self-funding arrangements of ADSO's proposal to be unreliable. But, more concerning, was that it considered administering and regulating the veteran support system is a core, non-commercial function of government and currently funded by taxpayers. This view ignores the historic role ESOs have played in supporting veterans and their families with little, if any, contribution from government. The Productivity Commission dismissed the assertion its statutory model would lack independence in the claims and decision-making process, likening its proposed system to that of Centrelink and the Australian Taxation Office, which have similar double functions.

The Government has yet to make decisions on the recommendations contained in the Scoping Study and Productivity Commission submissions. ESO representatives on DVA's Ex-Service Organisation Round Table unanimously do not support the Productivity Commission's recommendation for delivering advocacy services deeming it to not be in the best interests of veterans and their families.

The Association considers the proposal to be seriously flawed for practical reasons. It appreciates there are likely many opinions for a suitable veteran support structure that will meet the needs of Australian veterans today and in the future. Consequently, the Association is continuing to urge major ESOs and the Government to consider viable alternatives to the Productivity Commission's statutory model for veteran advocacy and support services.

It's true that ESOs have acted disparately in the past. However, there is a growing widespread realisation that no single ESO can meet the advocacy and other support service demands of the veteran community. The future lies in closer collaboration among ESOs, Defence, DVA and other agencies.

AFA INITIATIVES

The Association's modernisation program, Project High Eagle, got underway with the inaugural meeting in November last year of the Joint Boards Steering Group (JBSG), which is a sub-committee of the AFA Ltd National Board.

The meeting was a milestone event with State/Territory Division representatives unanimously seeking ways to improve the Association's operation, including increased support for veterans and their families.

The Association will work to strengthen its ties with the Air Force Family and other ESOs to optimise its support efforts. The JBSG met again in Canberra in February, coinciding with the Association's 100th Anniversary Dinner and National Board Meeting.

In keeping with the Association's commitment to support our veterans, DVA and Defence have been advised we are supporting the ADF Firefighter Action Group's request for recognition of the health conditions of ADF Firefighters who trained at the former RAAF Fire School that operated for several decades at the Point Cook base. Issues with complex veterans' support legislation and sparse epidemiological evidence linking their exposure to a cocktail of various carcinogens to myriad cancer and deadly non-cancerous conditions have thwarted the group's decade long bid for a resolution.

Statistical data reveals these former serving members have a considerably higher death rate than the average Australian male, especially in the 50-to-70-year age cohort.

The Association is assured these aging and many extremely ill veterans have a genuine grievance and have suffered through no fault of their own in the execution of their duty.

This year promises to be a busy year for the Association. I expect it to be productive. The National Board looks forward to successfully influencing the shape of a better system to support veterans and their families, which will be a hallmark of our centennial year.

Remembering the BATTLE OF BRITAIN

SOME MAY WONDER about the significance of the Battle of Britain to Australia today. Afterall the Australian involvement was not overly great; more Australian airmen were lost in one raid by Bomber Command than in the entire Battle of Britain.

However, it was the first battle in the history of armed conflict conducted substantially by air forces – and this a mere 40 years after the first flight by the Wright Brothers at Kittyhawk.

Not only was it the first great air battle, but also one of the most decisive battles of World War II. Furthermore, it was the prelude to the dramatic rise of air power which has, today, become the predominant instrument of armed conflict.

It is therefore an appropriate anniversary on which to commemorate the deeds and sacrifices of Australian, and indeed all, airmen in all conflicts, past and present, friend and past foes alike.

Let me remind you of some details of this critical battle in the annals of air power.

In the summer of 1940, the European theatre of WWII took on a new phase. Most of Europe had fallen to the German Nazi military might. Hitler was then confronted with the problem of invading Britain. Not since the Spanish Armada in 1588 had the British people fought to protect their island state. The Luftwaffe was given the task of preparing for such an invasion.

The Battle of Britain was principally an air battle. It fell into three phases, beginning on 10 July 1940. The first and second involved the Luftwaffe's attempt to destroy British fighter strength, first by attacks on ports and coastal shipping and secondly by assaults on airfields. With the failure of this plan, the Luftwaffe finally turned on the cities.

Remembered as the climax of the battle, 15 September saw all British reserves committed to the fight. Fortunately, Fighter Command was able to inflict decisive losses on the enemy and hold off the prospect of invasion. The battle had turned. Britain was safe, making possible the eventual defeat of Nazi tyranny.

But let us also remember the sacrifices of our then foes who were fighting for their country and also suffered the terrible consequences of war.

This will be the 41st year a Battle of Britain Commemoration has been held in Hobart. How did all this start?

Prior to 1980, the RAAF commemorated Air Force Day on the anniversary of the Battle of Britain – 15 September. It then decided the RAAF's birthday would be a more appropriate day and so the Battle of Britain faded away.

However, many thought that the Battle of Britain deserved continued recognition and late in 1978, two RAAF Reserve Officers, then Air Training Corps instructors and members of the RAAF Association, Carroll James and Alan Robertson took the initiative to restore the commemoration. The Senior Air Force Officer at the time, Wing Commander Kevin Murray, recognised the importance of the Air Force anniversary and joined Carroll and Alan in forming a small private committee.

In 1979, invitations were sent to serving and former members of the Defence Force to the inaugural dinner, intended to be a fundraising event for the Air Training Corps cadets. Group Captain Russ Law was the first guest of honour.

In 1980, the Senior Air Force Officer, Wing Commander Wayne Parsons took the view that such an event should be sponsored by the RAAF and he obtained resources to manage the dinner and support the RAAF Association, which organised the church and cenotaph services.

Over the years the dinner has outgrown many venues: the Naval, Military and Air Force Club, the Commonwealth Centre, University and the Royal Yacht Club. For us, the present location Elwick Function Centre has ticked all the boxes.

Just prior to the 60th anniversary in 2000, the RAAF in Hobart was significantly downsized. Consequently, at the dinner that year, their representative announced this would be the last B of B dinner.

I was State President at the time and our guest of honour was our then Governor, His Excellency Sir Guy Green who was seated beside me. On hearing this announcement, he turned to me and said, "Peter you have to keep this important function going".

So, I suppose the RAAF Association in Tasmania was then under Vice-Regal order and from then on has been responsible for all associated events – church, dinner and cenotaph – and we have done so with wonderful, and essential, support from the RAAF, including of course, No.29 Squadron.

At one stage, the RAAF questioned the ongoing significance of the occasion. That's when we changed

ABOVE Royal Australian Air Force, Chief of Air Force Air Marshal Mel Hupfeld, AO, DSC salutes at the Cenotaph in Hobart during the 79th anniversary commemoration of the Battle of Britain.

the focus from the battle itself to the commemoration of air forces and air power on the anniversary of the first great air battle.

A few years ago, the Association's National Council, recognising our efforts over so many years, declared that the Hobart commemoration would become the national event.

When Air Chief Marshal Mark Binskin AC was CAF, he announced at the cenotaph service that the Hobart commemoration would become part of the Air Force tradition and subsequent Chiefs have continued to be most supportive. We thank the present Chief, Air Marshal Mel Hupfeld, AO, DSC for agreeing to continue that support.

The Hobart commemoration is part formal and part informal. It commences with an informal gathering at the RAAF Associations' Memorial Centre, the following day a specially focused service in St David's Cathedral, followed by a formal dining-in night. Finally, a wreath laying service at the cenotaph followed by an informal barbecue lunch at the Memorial Centre.

The RAAF provides considerable support: the band, aircraft for the flypast, No.29 City of Hobart Squadron and No.5 Wing AAFC. In recent years we have also had wonderful support from the Attaché Corps in Canberra.

• Peter Scully, AO, Air Vice-Marshal RAAF (Ret), Chairman, Battle of Britain Commemoration Committee; Past State President RAAF Association (Tasmania Division)

The 80th anniversary of the Battle Of Britain will be commemorated in Hobart 11-13 September, 2020. For details visit raafatas.com.

CENTENARY CELEBRATION FOR THE AIR FORCE ASSOCIATION

ABOVE CAF Air Marshal Mel Hupfeld addresses 100th anniversary dinner guests.

On Wednesday evening 26 February, the Air Force Association held a formal dinner to mark the 100th anniversary of the original event that sparked the formation of the Association. That event was an informal dinner arranged in Melbourne to honour Sir Ross and Sir Keith Smith and their crew, Sergeants Jim Bennett and Wally Shiers, following completion of their Epic Flight from England to Australia (serialised in the past three editions of *Wings*, concluding in this issue).

The dinner was attended by many of the Smith brother's former Australian Flying Corps (AFC) comrades, including Lieutenant Colonel (later Sir) Richard Williams who had commanded No.1 Squadron AFC during World War I, and who was destined to become the first Chief of the yet-to-be-formed Royal Australian Air Force. Following the dinner, attendees agreed to create the Australian Flying Corps Association in Victoria, formally established in 1921, with similar Australian Flying Corps Associations established over the following months in the other states.

Exactly 100 years later, on 26 February 2020, the Air Force Association marked the centenary of this significant event with a formal dinner at the Vibe hotel in Canberra. The Association was honoured to have the current Chief of Air Force, Air Marshal Mel Hupfeld, AO, DSC, as the guest of honour, as well as the former CAF and CDF, Sir Angus Houston, AK AFC.

In his address, Air Marshal Hupfeld referred to the significance of the Epic Fight in that era of aviation as akin to the first man landing on the Moon 50 years later. He noted that the qualities displayed by those four aviators; grit, courage and the highest standards of excellence were the same values the modern Air Force has adopted and espouses for all its people.

Significantly, CAF also empathised the importance of current members learning their history and the role of the Air Force Association in facilitating important personal contacts with former members; contacts that he had valued as a junior officer.

FLGOFF KENNETH CHARLES TWEEDIE, DFC

8 January 1923 - 30 December 2019

ON 30 DECEMBER 2019 KEN TWEEDIE, DFC, passed away peacefully in Townsville just a week before his 97th birthday. Ken was an inaugural member of the Air Force Association, Townsville Branch, and a volunteer at the RAAF Townsville Heritage Centre.

Kenneth Tweedie was born in Blackpool, England in 1923, emigrating to Adelaide in 1925 with his family. Ken was studying at the Adelaide Teachers College when the world descended into war. A sense of adventure and patriotism lured him into the RAAF, enlisting on 6 December 1941. He was posted to the Empire Air Training Scheme graduating as an Air Observer qualified as a Navigator, Bomb Aimer and Air Gunner.

He embarked for the UK in 1943 and, following conversion to the Lancaster bomber as a navigator, he arrived at No.460 "G for George" Squadron on his 21st birthday. He completed 30 missions with that squadron operating over Berlin and deep in Germany. His crew were tasked for several missions in support of the D-Day landings. Allied High Command considered those missions "as having significantly weakened the German defences and saving countless thousands of allied soldiers' lives". He flew his last mission on 13 June 1944 and was awarded the DFC for his exceptional service.

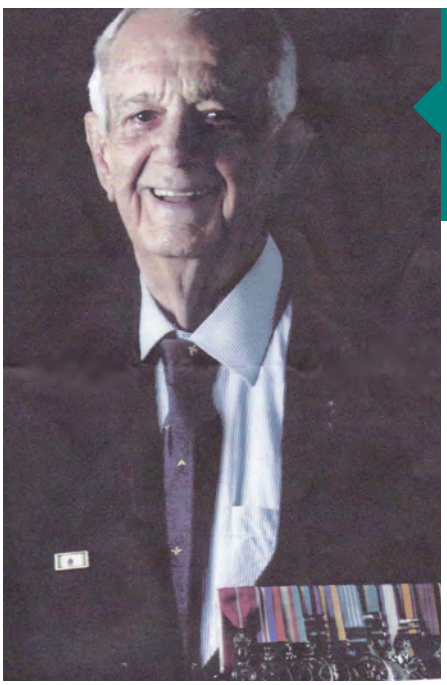
At the 70th anniversary of D-Day in 2014, the French Government announced that it would award the Légion d' Honneur Chevalier (Order of the Legion of Honour – Knight) to any living Veteran who could prove that they contributed to the liberation of France. In 2015 WGCDR Matthew Harvey, CO 27SQN (City of Townsville), presented Ken with the Légion d' Honneur Chevalier on behalf of the French Government.

Post-war life saw Ken lecture in physics at Wulfrun College, Wolverhampton, England. He enjoyed gardening, brewing his own beer and was known as the resident snake catcher at the RSL Villas in Rowes Bay. He will be sorely missed.

The Townsville Branch was privileged to be able to conduct the "Poppy Service" at Ken's funeral.

Thank you for your service Ken, RIP.

• Basil Nelson, Secretary, Air Force Association, Townsville Branch



SQUADRON LEADER VINCENT JOSEPH O'BRIEN MBE (RET'D)

?? 1926 - 24 January 2020

VINCENT JOSEPH O'BRIEN, known to the world as "Dinny", a nickname he was given when he first arrived at Williamtown in 1946, was born in 1926 at Cowra, New South Wales.

After leaving school he joined the local Air Training Corps in 1942 and remained a cadet until joining the RAAF at Sydney on 18 July 1944. Basic (Rookie) Training, initial Engineering & Trade Training (Flight Rigger) was completed at Cootamundra, Adelaide and Ascot Vale.

First Operational posting was to No.8 OTU, Parkes, NSW, working on Spitfires until the end of WWII. After a brief period at No.5 SFTS (Service Flying Training School), Uranquinty, he was posted for discharge to Bradfield Park, Sydney. However, Dinny signed a two-year contract to serve in the Interim Air Force and was posted to 31 Squadron, Williamtown. The 31 Sqn posting was abandoned and in March 1946 he was transferred to Crew Conversion Unit (CCU) to work on Mosquito, Wirraway

and Mustang aircraft. He remained at Williamtown until May 1947 then completed Fitter 2A (Airframe Fitter) course at Wagga Wagga.

Shortly after returning to Williamtown he was posted to 481 (M) Squadron at Bofu and Iwakuni, Japan, as a member of the British Commonwealth Occupation Force (BCOF) where he remained until December, 1948. While in Japan, his Interim Air Force contract expired and he was "conned" into joining the Permanent Air Force (PAF) for 12 years. On return to Williamtown he served at No.78 Wing until posted back to Japan on 7 July 1950 to No.77 Squadron at Iwakuni.

His posting to Japan was associated with the Korean War. During that period he served in both South and North Korea as part of the United Nations (UN) Military Force. In October 1950 at Pohang in the South, up near the border with the North, he was heavily involved in operations near the North Korean capital of Pongyang which was captured in October 1950.

On 16 November 1950, 77 Squadron moved up into North Korea to an airfield at Yongpo near Hamhung. However, the Chinese and North Korean Forces stared pushing the UN forces south. As they moved ever closer to Yongpo all ground personnel were ordered to carry firearms in order to defend the base. It was a tense situation. Dinny was promoted to the rank of Corporal at that time.

The weather at Yongpo was atrocious, sub-arctic conditions where a bare hand would stick to the skin of an aircraft. On 3 December the Squadron was told to bug-out. Squadron aircraft left in a hurry and the ground crew and support equipment were evacuated in a rush by RAAF Dakota aircraft over the border to Pusan in the South.

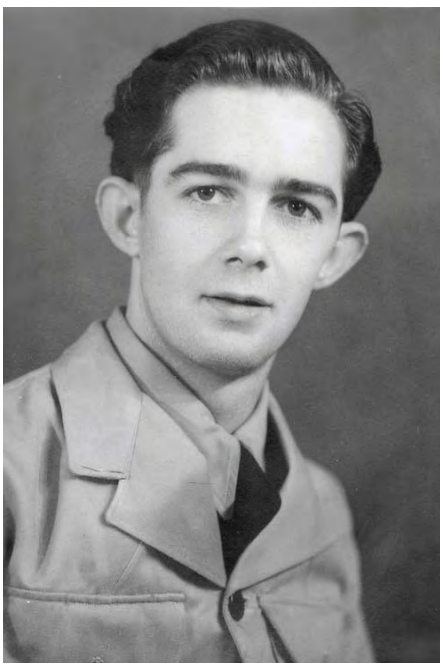
Dinny returned to 78 Wing and 2 OTU at Williamtown, and promoted to Sergeant in November 1954. He remained at Williamtown until posted to Officer Training School, at Rathmines in September 1957.

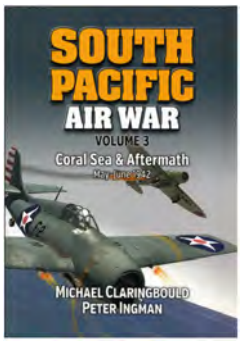
Postings after being commissioned included ARDU and 21 Squadron at Laverton then RESENG CAC, Fishermans Bend, Melbourne. In January 1961 he was posted to the staff of the Mirage Project and remained with the project in Paris until returning to Williamtown in July 1964. The remainder of Dinny's service, with the exception of a tour as SENGO 75 Squadron, Butterworth, Malaysia in 1969/70, was spent at Williamtown at various Units including 2OCU, 75 and 481 Squadrons. Dinny took early retirement in September 1977, having served for 33 years.

Dinny married in April 1950, 10 weeks before going to Korea. His son Craig was born at Newcastle in November 1952 and daughter Jane was born in July 1962 at Paris, France. He was appointed a Member of the Order of the British Empire (MBE) in 1974 and awarded the Queen's Silver Jubilee Medal in 1977.

One of Dinny's claims to fame is that he was one of the few ENGOs not to be posted to HQSUPCOM, HQOPCOM or Air Office but he did enjoy many attachments to Darwin, Townsville, Bali, Sale, Wagga, Learmonth etc. Dinny rounded off his Air Force career with two years (1981/1983) in the RAAFAR at Williamtown as Deputy CO during the formation of No.26 Reserve Squadron.

BELOW A young Dinny.





REVIEW BY Bob Treloar

SOUTH PACIFIC AIR WAR.

Volume 3, Coral Sea & Aftermath, May-June 1942

By **MICHAEL CLARINGBOULD & PETER INGMAN**

Avonmore Books, RRP $44.95

THE BATTLE OF THE CORAL SEA, well-known to Australians, has been recounted by numerous historians. This book, however, differs from earlier volumes on the subject by providing a complete coverage of the air-sea campaigns and battles in the South Pacific during the months of May and June 1942.

The authors are uniquely qualified to recount and assess the prosecution of that phase of the Pacific War. Raised in Port Moresby, Michael Claringbould is a globally acknowledged expert on the New Guinea conflict and both Japanese and United States Army Air Force aviation of that period. Peter Ingman is an acclaimed author of military history specialising in the early part of the Pacific War.

The Battle for the Coral Sea was not a stand-alone action. The complete action involved land-based aviation, both Allied and Japanese, in combat operations over New Guinea and against carrier forces at sea. The authors have brought together the campaigns conducted before and during the carrier battle, discussing the objectives of those campaigns and their ultimate effect on the way the carrier battle was fought by both sides. They have meticulously recorded the engagements and skirmishes within the various campaigns in an easy-to-read style.

Coral Sea & Aftermath, May-June 1942 provides a comprehensive account of the carrier battles, the air battles over New Guinea and Northern Australia, and enemy surface and submarine action along the eastern coast of Australia, as well as air-sea rescues of downed Allied airmen and shipwrecked sailors. It will appeal to all readers who have even a passing interest in military history. A most enjoyable read.

REVIEW BY Bob Treloar

VIETNAM'S FINAL AIR CAMPAIGN:

Operation Linebacker I &II, May-December 1972

By **STEPHEN EMERSON**

Pen and Sword Military, RRP $44.99

VIETNAM'S FINAL AIR CAMPAIGN describes a two-part air campaign conducted by the United States in North Vietnam in 1972 to bring the Vietnam War peace talks to a satisfactory conclusion. America was faced with a massive anti-war movement that was tearing apart the fabric of American society and President Nixon was facing re-election.

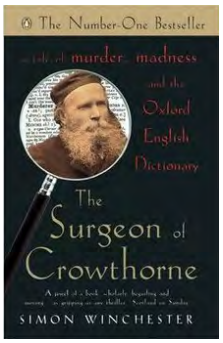
Sensing Nixon's quandary, the North Vietnamese Politburo launched attacks along the length of South Vietnam. Nixon retaliated with an air campaign against North Vietnam to bring the peace talks to a favourable conclusion and win America an honourable peace.

Linebacker I was conducted primarily with US Air Force tactical fighter and strike aircraft launched from bases in South Vietnam and Thailand; and by US Navy aircraft launched from a carrier force on station off the North Vietnamese coast.

Linebacker II was conducted mainly with B-52 strategic bombers. It was planned and led by professional airmen, unencumbered by the limitations imposed by the White House. It was decisive and had a devastating effect on Hanoi, Haiphong and the North Vietnamese military forces.

This well-researched, cogent and easy-to-read history of the air campaign includes excellent descriptions of fighter and bomber missions that enable the reader to glimpse the complexity and lethality of fighter tactics and defensive counter-air defence measures.

Author Stephen Emerson has worked as an intelligence analyst covering political-military affairs in Africa and the Middle East. He has served as an associate professor at the United States Naval War College in Newport, Rhode Island.



REVIEW BY Carl Schiller

THE SURGEON OF CROWTHORNE

A Tale of Murder, Madness and the Love of Words

By **SIMON WINCHESTER**

Penguin Books, RRP $24.99

IN THE EARLY 1800S there were few English language dictionaries and those that existed were incomplete. Also, the English and French languages were in competition to be the dominate world language. In 1879, the Philological Society of London, on agreement with Oxford University Press and Professor James Murray, began to develop the Oxford English Dictionary (OED).

The OED was planned as a four-volume 6,400-page work comprising all English language vocabulary from 1150AD onwards, but the lexicographers had only reached the word 'ant' five years into a 10-year contract. Murray's team came to realise the complexities of the English language and that it never stops evolving.

The OED's development relied on volunteers providing words and quotations to illustrate definitions, but who would have imagined the greatest single contributor of some 10,000 entries would come from American Civil War Union Army Surgeon, Dr William Minor, a convicted murderer, who was suffering from major mental health disorders. Murray considered Dr Minor a "practicing medical man of literary tastes with a good deal of leisure". He had no idea Minor was being held in the Broadmoor Criminal Lunatic Asylum. Nevertheless, even after Dr Minor's circumstances were revealed, he became Murray's most reliable and trusted source of words.

The book is a gripping story of murder, insanity and the precise meaning of words and, in the end, one in which Winston Churchill plays a part. It was nominated for the National Book Critics Award for General Nonfiction. I rate it five out of five stars.

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