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The History of the Australian Aerospace Industry

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ABSTRACT

The Australian Aerospace industry began with the work of Lawrence Hargrave in the late 19th century, which preceded and most likely influenced the first aeroplane ever built. Throughout the early 20th century Australian aviators such as Bert Hinkler and Sir Charles Kingsford Smith made history by completing record-breaking flights all over the world. The Royal Australian Air Force and later the RAAF played an important role in both World Wars, aiding allied troops in locations as diverse as Europe, the Middle East and China.

Australia’s size and scattered population made it important to establish an aviation industry as early as possible. Commercial aviation began in 1920 when Qantas was founded, later on; Australia became home to the world’s first flying doctor service. To this day, both Qantas and the Royal Flying Doctors Service are still operating.

Throughout the 1950’s and 1960’s, the outback town of Woomera in South Australia became an important testing ground for the Australian and British military. Later on it was used as a base to launch a number of rockets and satellites. More recently, the Woomera range has played host to the University of Queensland’s HyShot Hypersonics program and is slated to become the launch site of the Kistler K1 reusable launch vehicle. Australia’s reputation as a pioneer and world leader in the aerospace industry will ensure that Australia continues to be successful in the aerospace industry.
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1 INTRODUCTION

Although Australia as a nation is relatively young in age and small in population, its space and aviation industries are far from undeveloped. To the contrary, Australia has one of the most active and developed aerospace programs in the World, including the HyShot program, a world leading research program into scramjet technology. In addition, Australia has one of the most up-to-date and ‘cutting edge’ air forces in the World – the RAAF, not to mention its defence industry, each worth billions of dollars to Australia’s economy.

The Royal Australian Air Force (RAAF) is the second oldest air force in the world, following the Royal Air Force of Britain. It was established in 1921, thus making it 86 years of age. However, its roots extend right back to 1912 at Point Cook in Victoria and the formation of the Central Flying School. Unquestionably, it was the technological development of the RAAF and the need for Australia to keep up with the enemy during the World Wars that saw the aviation industry in Australia come to fruition. As the prospect of a Second World War grew and tension between nations mounted, it became evident that Australia did not have the air-power necessary to protect its large coastline nor assist the Allied effort overseas. This saw the spark of the aviation boom in Australia, and from there, the rest is history.

After the conclusion of the Second World War, it was commercial aviation that came to the forefront of air travel in Australia. This period saw the rise of an Australian airline giant, QANTAS (Queensland And Northern Territory Aerial Services), which today has become the third oldest continually running airline with the best safety record of any airline in the World.

The development of defence and civilian air travel within Australia has obviously seen the involvement of some very famous and well known aviators. Such names as Sir Charles Kingsford Smith, Lawrence Hargrave, Herbert John Louis Hinkler, Sir Ross and Sir Keith Smith, Nancy Bird Walton and John Flynn are common ‘house-hold’ names because of their contribution to the Australian Aviation Industry.

The Australian participation in space research and exploration may seem small and overshadowed by larger countries such as Russia and the United States of America. However, Australia has played some pivotal roles in the Space Industry, particularly in the area of testing and launching. The testing and launch range at the Woomera Space Port is the biggest in the world and consequently is attracting local and foreign companies alike to use these facilities. Kistler Aerospace is one such company seeking to use the facilities at Woomera to launch its reusable launch vehicle, the K1. It is events such as this that will provide a huge boost to Australia’s Space Industry and allow Australia to play a continually prominent role in Space research and exploration.

This report will provide an insight into the history of both the Australian aviation and space industries, focusing on the events which made them what they are today. It will also examine the future of the Australian Aerospace industry and look at what part Australia can play in the development of this rapidly growing industry.
Ever since the Second World War, Australia has been used extensively in the testing and launching of rockets, missiles and other projectile-craft. However, it has often been foreign companies who have been performing these tests and launches, not Australian organisations. This demonstrates uniqueness about Australian conditions that make it a suitable location for testing and launches as opposed to other countries around the world. There are two main factors crucial in selecting a location for a testing and launch facility. These are, the location of the site relative to nearby surroundings such as towns and the environment associated with this location such as terrain and weather conditions.

When selecting a site for a testing and launch facility the location relative to nearby surroundings is very important. In particular, isolation is desirable, as the site will host events such as rocket and missile testing where there is a high probability of a loss of control in testing [49]. When control over a test is lost, the rocket or projectile may perform in an unpredictable manner and could crash. In this case, the best scenario is for the crash to take place well away from any people or animals or anything else, which could be harmed. As an example, to illustrate this, if a rocket testing facility was built in a major city, and a test projectile lost control and crashed, the chance of the projectile hitting an innocent person or causing damage to nearby buildings would be high. This is due to the fact that the test facility has been built in an area of dense population. Similarly, a test facility built near a national wildlife park would be equally unsuitable due to the risk posed to nearby plants and wildlife. Consequently, a large isolated area is required when building rocket and projectile testing facilities.

The second factor that must be considered when selecting a launch site is the surrounding environment. As discussed above, we require an isolated area of land for a launch site but the environmental conditions associated with a particular location will greatly affect it suitability. Environmental conditions cover a wide range of factors but more importantly, climate and terrain.

Climate is an important consideration, as it will provide an estimate of the average weather conditions for a particular location. A climate that is unsuitable will have adverse effects on launches and tests. A suitable climate would include low rainfall, moderate to high temperatures, minimal cloud cover and low chances of extreme weather conditions such as high winds, storms, cyclones, snow and flash flooding to name a few [20]. To illustrate this further, a launch site that has been built in an area of high rainfall would be unsuitable as the chance of rain on a day of launch would be too high. Rain would hinder launch proceedings with the risk of water damage to equipment and components. Likewise, a launch facility built in an area with high cloud cover would also be unsuitable as cloud cover affects visibility, which will obstruct tracking and monitoring. Furthermore, because the weather is constantly changing, climatic launch conditions could change in a small space of time causing the launch to be abandoned at the last minute. Therefore, when selecting a launch site, we seek a dry location with a relatively clear sky and constant predictable climate conditions, as this will reduce the chance of the weather changing in an undesirable way.

The terrain surrounding a launch site affects procedures surrounding a launch such as rocket retrieval. As mentioned above, a large flat area of land is required for a launch site. This is not because the launch itself requires a large area; rather events succeeding the launch can occur well away from the launch tower [44]. The Kistler K1 is a good example of how flat terrain is important, as the K1 is a
two-stage rocket that is fully reusable. Hence, both stages of the rocket return at some stage to the launch site. However, they do not return to the exact positions where they were launched, they may land kilometres away and will therefore need to be retrieved. If the terrain between the launch site and the drop down position of the K1 stage is too rough and uneven, retrieval will be very difficult and expensive. Conversely if the terrain is relatively flat, then this makes the retrieval process much simpler.

As discussed above, it is clear that launch and testing facilities for rockets and projectile cannot be built anywhere. In fact, there are few places in the world that satisfy the criteria previously described. However, there are regions in Australia that are suitable for launch sites. An example of this is the Woomera Space Port, which is Australia’s primary launch facility. Woomera is located north of Adelaide and consists of a prohibited area known as the Woomera Prohibited Area (WPA). Originally the WPA covered 270 000 square kilometres but over time, it has been reduced to 127 000 square kilometres which is comparable to the area of England and hence, the WPA is the largest land rocket testing range in the world [26]. In fact, Woomera was a much more isolated place when it was first built; it is only due to influences such as the mining boom that other towns have developed around it. This demonstrates one of the reasons why Australia is suited to rocket and projectile testing. Australia has very low population density of approximately 2.5 people per square kilometre compared to 52 people per square kilometre in Europe [39]. Furthermore, the vast majority of Australia’s population lives closer to the coast meaning that the population density decreases as we move inland. This effectively implies that if a projectile testing range was to be built in Australia, the number of people living in the vicinity of the range will be much lower than for a country such as England or the United States of America. The low population density also implies that if a projectile test was to fail, the chance of somebody being hit is much lower than other countries with a higher population density. Hence, we can say that there is a much greater opportunity of finding a large area of land that is uninhabited in Australia than in highly populated countries particularly given Australia’s population bias around the coastlines. Australia is also the flattest and with the exception of Antarctica, the driest country in the world [32]. Once again, these characteristics are enhanced as we move inland. Therefore, Australia is the driest and flattest country in the world, which has great advantages when selecting a launch site. Firstly, with Australia being the flattest country in the world, there will be a greater number of large flat locations than some of the more mountainous countries in the world. Secondly, the dry conditions in Australia mean that our average weather conditions are finer and there is less chance of rainstorms or other climatic extremes. This will provide launch sites with clear visibility for testing, monitoring and tracking and will reduce the chance of a launch being cancelled due to foul weather conditions.

The climatic, geographic and geological characteristics of Australia present it as a prime location for rocket and projectile testing. Woomera is currently the primary rocket testing range in Australia but owing to the countries size and population density and distribution; there are other possible locations for launch and testing sites. Due to the distribution of Australia’s population, inland Australia serves as a better location for testing than places around the coasts. Australia’s weather conditions also change somewhat as we move inland and provide the dry conditions that are desirable. Hence, inland Australia is the most suitable location for a rocket testing range. As to specific sites, it is simply a matter of finding an isolated flat location away from any pre-existing towns, natural habitats or establishments. Areas in central Western Australia could provide such locations as well as central Australia above and around Alice Springs and into the Northern Territory and also areas around central Queensland.
The criteria which must be satisfied when selecting a rocket and projectile launch site is somewhat specific. A large flat and isolated area is desirable with clear weather conditions, low rainfall and a reduced risk of climatic extremes. Australia satisfies much of these criteria, as it is the driest and flattest country in the world with a very low population density. This is why Australia is very suited to rocket and projectile testing.
Woomera, an experimental missile and weapons defence testing area was established in April 1947 by the British and Australian governments. Following World War II the British government required a large, remote area in which to test weapon systems, Woomera was chosen over various other sites due to its vast and virtually unpopulated location. The Woomera Test Facility (WTF) restricted area initially covered two large areas, one approximately 500km north of Adelaide, the other in northern Western Australia. This was reduced in 1972 to an area of 127,000km$^2$ north of Adelaide, with the Western Australian test area decommissioned. While reduced in size, the WTF is still the largest missile testing range in the world.

Woomera has a current population of about 200 people, with a maximum population of 6000 that occurred during the 1960s. Due to its very dry location, additional water for the camp is piped in from the Murray River.

Initially commissioned for a rocket range, the Woomera Test facility soon became home to all varieties of weapons and vehicle testing. Early tests included the British blue-streak missile project as well as thousands of bomb and explosive tests.

The blue-streak missile was Britain’s attempt at developing a long-range ballistic missile, which could be fitted with an atomic warhead. Tests began in 1955 and were finally cancelled in 1960. This cancellation came about due to the realisation that the rocket would have limited effectiveness in practice. Fuelling of the rocket took 15 minutes, too long for a rapid response attack. Due to the long fuelling periods, it was planned to launch the missiles from silos, however finding suitable locations for these silos proved difficult. While the rocket was deemed unsuitable as a weapon, the rocket became the first stage in the Europa project, which was also undertaken at Woomera.
Following on from the failed Blue-streak rocket project came the Europa project. The Europa project was started to begin development of a satellite launch vehicle for Europe. This project was run jointly by several European nations coming under the heading of ELDO, short for European Launcher Development Organization. The countries involved included Britain, France, West Germany, Italy, Belgium, Netherlands and Australia for providing the launch facilities. Each of the countries was assigned a different section of the launch to manage. Britain had modified its Blue-streak rocket to become the first stage of the launch vehicle; France was to manage the second stage with Germany taking control of the third. Italy was in charge of satellite development, while the Netherlands and Belgium were jointly working on Tracking and Telemetry. Standing at 35 meters high and weighing 105 tonnes, the Europa rocket was the largest ever launched at the Woomera Test Facility.

The Europa project was split into three distinct phases: First, Launching of the Blue-streak first stage into Western Australia from South Australia. Secondly, Launching with dummy first and second stages into Northern Territory desert from South Australia. Third, launching of all complete stages including satellite, attempting to get satellite into orbit.

The first phase of the project involving three launches of the first stage into Western Australia were all successfully completed in 1964/65.

The second phase involved four launches including dummy stages took place in 1966/67. The first two tests in this phase involved both 2nd and 3rd dummy stages, the second of which was successful. The third and fourth tests involved an actual 2\textsuperscript{nd} Stage and a dummy 3\textsuperscript{rd} stage. On one of these tests, the 2\textsuperscript{nd} stage failed to ignite and on the other, the first and the 2\textsuperscript{nd} stages failed to separate.

The final three launches of the Europa project were part of phase three, attempting to get a satellite into orbit. In 1968 and 1969 the first two of these attempts resulted in the third stage exploding. The third launch was partially successful, with all stages operating as expected, but with the satellite failing to reach orbit. A final 11\textsuperscript{th} launch was planned and never took place. After 1970 European launches moved to French Guiana, now home to Ariane launches.

In the late 1960s, as the Europa project was coming to an end, the viability of Woomera was coming under scrutiny. The creation of Nurrungar, the United States Airforce communication centre, 19km south of the Woomera village, ensured its future. Operations at Nurrungar ceased in 1999.
Currently, the Woomera Test Facility contains three main test ranges and Areas. These areas are the Ordinance Impact Testing area, Explosive Areas and the Instrumented Range. The Ordinance Impact area is primarily used for testing live and inert ordinance from ground and air-based launches. There are two main Explosive areas, one for the testing of large scale explosives, the other primarily used for the disposal of expired and bulk explosives. The Woomera Instrumented Range is the area most readily associated with Woomera. The Instrumented Range is the primary location for rocket launches and contains offices and instrumentation buildings.

The Woomera test facility is readily available for use by government agencies and commercial organizations by application.
4 THE HySHOT PROGRAM

Launching rockets into space is currently a very expensive exercise. This cost effectively comes down to the amount of weight that you wish to launch. Futron Corp (2002) estimates the average cost to achieve Lower Earth Orbit (LEO ~ 100km) is between 2,000 USD and 8,000 USD per pound of mass launched. To achieve a Geosynchronous Transfer Orbit (GTO) the cost escalates even further.

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>LEO</th>
<th>GTO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Western</td>
<td>Non-Western*</td>
</tr>
<tr>
<td>Small</td>
<td>$8,445</td>
<td>$3,208</td>
</tr>
<tr>
<td>Medium/Intermediate</td>
<td>$4,994</td>
<td>$2,407</td>
</tr>
<tr>
<td>Heavy</td>
<td>$4,440</td>
<td>$1,946</td>
</tr>
</tbody>
</table>

* The Zenit 3SL is considered a non-Western launch vehicle because of its Ukrainian and Russian heritage.

Table 4.1: Average Price Per Pound for Western and Non-Western Launch Vehicles [17]

This large cost is the main reason behind the development of new, advanced propulsion systems that can dramatically reduce the weight and thus the cost of space vehicle launches.

The development of an advanced hypersonic (for speeds of greater than Mach 5.0) propulsion system has been underway for the last 20 years at the Australian Centre for Hypersonics located at the University of Queensland. The HyShot program began as a research initiative into supersonic combustion. The first HyShot rocket, utilising a 2-stage rocket, was launched in October 2001. Since the first launch, the program has developed a high profile in Australia and internationally. The HyShot program is widely regarded as a world leader in scramjet technology.

4.1 The Supersonic Combustion Ramjet

The Scramjet engine was designed to give high-speed performance (normally found in rockets) to an air-breathing engine. Alternative air-breathing propulsion systems, such as the jet engine and the Ramjet engine offer good low speed performance but suffer performance issues at high speeds. These performance issues include increased drag and inefficient burning of fuel due to the high temperatures generated.

A “Scramjet” or Supersonic combustion ramjet is a type of air breathing engine that takes the oxygen needed for combustion from the earth’s atmosphere. In order to discuss scramjet technology it is first necessary to examine the ramjet. Ramjets are designed to operate at supersonic speeds, a front facing engine inlet allows supersonic flow to enter a diffuser. The diffuser reduces flow velocity to subsonic speeds, air then enters the combustion chamber where fuel is injected into the flow and combustion occurs. As the exhaust air exits the engine nozzles it accelerates and creates positive thrust. The engine has no moving parts and unlike turbojet and turbofan engines, which must use compressor and turbine to compress the air/fuel mixture, the ramjet uses the high dynamic pressure at the inlet to compress the air.
To increase air and fuel mixing and to get an even flame throughout the combustion chamber, flame holders are used. Ramjets are capable of operating at their ideal air/fuel ratios because there is no requirement to keep exhaust temperature low, as there is no exhaust turbine. A strong shockwave is formed when air velocity is reduced through the diffuser; the inlet is specifically designed to generate an oblique shockwave and a normal shockwave, which act to both slow the air and increase pressure inside the combustion chamber.

Ramjets produce little thrust below speeds of around Mach 0.5 and are highly inefficient at speeds above Mach 5 due to the shockwave at the inlet. Thus for hypersonic applications (>Mach 5), combustion needs to occur at supersonic speeds as this reduces the inefficiencies caused by the shockwave [9].

Scramjet engines differ from the ramjet in that there is no diffuser in the inlet, the inlets are slightly different and scramjets use hydrogen as fuel rather than kerosene. Scramjets are more efficient over a wider range of speeds.

As speed increases so does temperature, the shockwaves produced by the leading edges of the engine can cause surface temperatures of up to 2700°C [2]. This is beyond the melting temperatures of most materials and therefore requires that scramjet engines be cooled if they are to last for more than a few seconds.

A disadvantage of both ramjet and scramjet engines is that they produce no thrust at low speeds and must use other propulsion to get them to the correct speed where dynamic pressure is large enough for combustion to occur. Auxiliary propulsion is typically achieved through the use of rocket engines, either liquid or solid fuelled which are easily capable of reaching hypersonic speeds.

The main benefit of the SCRAM jet engine is its use of atmospheric oxygen as the oxidiser in the combustion reaction. In conventional rockets, the oxidiser is carried within the vehicle, meaning the Scramjet is inherently lighter.

Ramjets and scramjets are not new technologies; theoretical studies on the feasibility of scramjets began as early as the 1940’s in the United States. However, scramjet knowledge has progressed slowly mainly due to other technologies not being available. For example hypersonic wind tunnels and shock tunnels where experiments could be carried out at hypersonic speeds and materials that can withstand the extremely high temperatures associated with hypersonic flight.
4.2 The Australian Centre for Hypersonics

The Australian Centre for Hypersonics was formally established in 1997 and is regarded as one of the leading research centres in hypersonic propulsion. Located at the University of Queensland, the centre was the first to develop a scramjet engine that could produce more thrust than drag in 1993. The HYSHOT II rocket launched in 2002 was the first to demonstrate supersonic combustion within a scramjet engine.

One of the main reasons behind the University’s success is their T4 shock tunnel. The shock tunnel was commissioned in 1987 and fired its 9000th shot on 13th March 2006 [47]. The T4 shock tunnel is one of very few in the world and can be used to generate sub-orbital flow conditions of up to Mach 10. The Scramjets launched in the HyShot rockets were all tested extensively within the T4 tunnel before launch.

The University of Queensland also operates its own launching pad in Woomera; a testing facility located roughly 500km north of Adelaide in South Australia. Woomera is an ideal location for a launch facility, located in a largely uninhabited area of central Australia.

The Australian Centre for Hypersonics has strong links with numerous countries around the world, including the US, Japan, Germany and the UK. The scramjet engines used in HYSHOT III and IV launches were developed by British defence company QinetiQ.
4.3 HyShot Launches

Before launched, the HyShot scramjet and components were extensively tested in terms of shock response, vibrations, vacuum testing and structural integrity. While the simulated environment generated within the labs and the T4 shock tunnel is a good representation of supersonic flows, it cannot recreate exact conditions of the atmosphere. As such, the HyShot test launches were a crucial step in gaining an understanding of supersonic combustion in practice.

To date, there have been four HyShot launches, all of which have been launched from the University of Queensland launching site in Woomera. These preliminary launches were designed to gather information about the pressure distribution to correlate with the data obtained from the test tunnel. As such, the primary objective of these launches was not to generate thrust, but to obtain data and demonstrate the feasibility of the scramjet engine. HyShot 3 was specifically designed to determine whether the air-inlet would allow the combustion chamber to auto-ignite.

The scramjet engine used in the 3rd and 4th launches was developed jointly with British defence company QinetiQ. The silver bullet shaped engine is mounted on the top of the second stage Orion rocket. During launch, the scramjet engine is covered with a nose cone, which is jettisoned when the rocket is near to the edge of the earth’s atmosphere. On the first two HyShot launches (I & II) the scramjet used was two dimensional in design. This configuration was designed to enable easier correlation with the T4 test tunnel data. The last two HyShot launches (III & IV) used a more complex cylindrical scramjet configuration developed by QinetiQ.

![Hyshot IV Pre-launch (Chris Stacey, 2006)](image)
Each of the launches utilised a 2-stage Terrier-Orion rocket system. Firstly, the terrier rocket is ignited, propelling the rocket to 4000km/s in around 6s. The terrier stage is then released, allowing the Orion motor to further propel the rocket. When the rocket is near the edge of the earth’s atmosphere (~56km) the nose cone is blown off and it begins the manoeuvres required to point back towards the ground. This manoeuvring is achieved using nitrogen cold gas thrusters. The rocket reaches a maximum height of approximately 330km before it begins its descent under the influence of the earth’s gravitational field. The trajectory of the rocket is planned so that when it reaches an altitude of 35km on the return trip it is travelling at mach 7.6 (7.6 times the speed of sound). At this point the scramjet engine is supplied with hydrogen to allow combustion to occur. Hydrogen is supplied for 5s as the rocket descends to a height of 23km. Data from the burn is then sent to three recording stations located on the ground for analysing at a future date.

The first launch, HYSHOT I, suffered a loss of control leading to mission failure. This loss of control was attributed to a fin assembly located on the Terrier-Orion sub-orbital rocket. Due to this failure, the rocket did not reach the required height. This meant that during re-entry the rocket was not travelling fast enough for the scramjet to activate.

HYSHOT II, launched on the 30th July 2002, was the first launch to achieve supersonic combustion. This was the first time that a scramjet engine had successfully ignited outside of a test environment. HYSHOT III, launched four years later in March 2006 also achieved supersonic combustion using an auto-ignition design. The HYSHOT IV rocket was successfully launched 5 days after HYSHOT III with a slightly different scramjet configuration.
4.4 HYCAUSE

The Hypersonic collaborative Australian/United States experiment (HYCAUSE) is a collaborative research project involving Australian and United States engineers. The Australian Defence Science and Technology Organisation (DSTO) in collaboration with the Australian Hypersonics Initiative (AHI) form the Australian contingent of HYCAUSE. The American interest in the project comes from the United States Defense Advanced Research projects Agency (DARPA).

Like the HyShot launches, the HYCAUSE rocket consists of a 2-stage Talos and Castor sounding rocket. The rockets once again propel HYCAUSE to a height above the earth’s atmosphere where gravity takes over. Gravity accelerates the rocket as it descends, the scramjet being lit at a height of around 40km. The main differences between HYCAUSE and the HyShot launches is the speed at which the scramjet will be ignited and the design of the scramjet itself. The scramjet uses an inward turning axisymmetric design unlike any previously tested. Combustion at speeds of up to mach 10 (10 times the speed of sound) were believed to be possible with this configuration. In order to achieve this higher speed, the maximum height achieved by the rocket is increased from 330km to 530km.

The first of three planned HYCAUSE launches successfully took place on 15th June 2007. While the launch and flight were successful, data is currently being analysed to determine if supersonic combustion occurred. This data will then be compared with data obtained from test tunnels in Australia and the United States.

With another two HYCAUSE launches planned in the coming years, along with up to 10 other hypersonic [12] flight experiments in the next five years; Australia looks set to retain its place at the forefront of hypersonic research.
Kistler Aerospace was a company founded in 1993 by Walter Kistler and Bob Citron with the vision of creating a fully reusable space launch vehicle. Since its foundation, Kistler Aerospace experienced numerous setbacks mostly relating to a lack of funding. This drastically affected the development of their fully reusable rocket, the K1, as the company went into bankruptcy. However, in 2005, Kistler Aerospace merged with aerospace and design company Rocketplane Limited to form Rocketplane Kistler (RpK) [21]. Since this time, the development has advanced further than ever with NASA investing money into the K1 program as part of their Commercial Orbital Transportation Services (COTS). However, the future of RpK is still in doubt as they are once again experiencing financial difficulties forcing NASA to consider cutting their funding [10].

Kistler Aerospace played a significant part in relation to the development of the Australian aerospace industry; the chosen location for the testing and launch of the K1 was Woomera in South Australia [21]. This will prove to be a huge boost to the aerospace industry in Australia and in particular for the Woomera Space Port. The launch facilities at Woomera have experienced erratic usage since their inception during World War Two and so the possibility of RPK using the Woomera as their primary launch site is an exciting prospect. Rocketplane Kistler states that they intend to use the Woomera Spaceport as the main launch site for the K1 with flights to begin in late 2008. There is also the possibility of commercial flights to be launched from Woomera in the future. Not only will this provide a boost for the space industry in Australia, but it will also have favourable effects on Australia’s economy, tourism industry and international relations.

5.1 The K1 Launch Vehicle

The K1 launch vehicle is a fully reusable two stage rocket under development by Rocketplane Kistler. It is a unique launch vehicle as it focuses on cost reduction and reusability. A computer-generated image of the K1 can be seen below in Figure 5.1. The K1 was designed to partake in a wide range of missions such as delivering supplies to the international space station and carrying payloads such as satellites into different earth orbits including geostationary orbits. However, the beauty of the K1’s design is that after it has delivered its payload, the vehicle will return to earth to be reused. This presents many benefits when compared to some of NASA’s one shot rockets, which deliver a payload and are then discarded. Even the space shuttle is not fully reusable which adds enormous costs to missions [50].
As mentioned above, the K1 is a two stage rocket which allows the vehicle to produce the required thrust to reach a desired orbit. Furthermore, the K1 is powered by Aerojet/Russian NK-33 and NK-43 engines which are designed to be used 100 times [21]. At an altitude of 135,000 feet or approximately 121 sec after liftoff, the first and second stages separate where the first stage ignites a single engine and proceeds on a controlled decent back to earth to be collected while the second stage or orbital vehicle proceeds to orbit with the payload. The orbital vehicle is designed to deploy the payload and then re-ignite its engine and continue on a controlled trajectory back to the launch site. The landing procedure involves both stages of the K1 deploying several parachutes at an altitude of 10,000 ft to slow the decent velocity. Then, just prior to landing, airbags are deployed to soften the landing impact. The vehicle may then be prepared for flight again within a few days [21].

The applications of the K1 launch vehicle are vast as it can be used for missions ranging from satellite transportation to supply delivery to the international space station and with further research; there is the possibility that K1 technology could be used for passenger flights. However, the real beauty behind the K1 is the fact that it is designed to be fully reusable with engines that can be reused over 100 times. The advantages of the K1 system are huge when compared to the conventional launch vehicles in operation today. Many of the current launch vehicle in operation are known as one shot rockets which means that they deliver their payload to the desired location and are then discarded [16]. This presents huge costs when we consider that each time a payload is delivered into space, a brand new launch vehicle must be used. Even vehicles such as the space shuttle present huge operating costs as it is only partially reusable and the cost of maintenance and testing to ensure that the space shuttle remains reliable and save is enormous. This is partly due to the fact that much of the technology in the space shuttle is well over thirty years old [16]. This is where the K1 launch vehicle presents a
welcome alternative with more modern technology when compared to some of the vehicles currently
in use. In addition, the K1 offers full reusability, which is particularly appealing as the need for
sustainability in industry becomes increasingly more crucial. Both of the two stages of the K1 will
return to earth to be retrieved and reused around one hundred times. This effectively means that the
K1 launch vehicle can take the place of one hundred one shot rockets and this will reduce costs and
material usage, which will place less strain on our natural resources.
6  FUTURE OF THE AUSTRALIAN SPACE INDUSTRY

Up until recently, world developments in the space industry have been restricted to large powerhouse countries such as Russia and the United States of America. This is due to the huge costs associated with space research and exploration. However, it is becoming clear, that the space industry is the way of the future and hence, more and more countries are becoming involved. Countries such as Australia can now play a significant part in space research and development and take a leading role in the future of the space industry.

The short term future of the Australian space industry lies with projects such as Rocketplane Kistler’s development and launch of their fully reusable rocket, the K1 particularly as the need for sustainable industry is becoming increasingly more important especially due to the current environmental crises in the world such as global warming. Launch vehicles that can only be used once should now be considered ‘old’ technology as multiple use vehicles will save money and resources and hence make developments in the space industry more affordable and achievable. The applications of the vehicles like the K1 are vast and will continue to grow especially if space research and exploration extends to places such as the moon. The K1 launch vehicle would be an excellent vehicle to transport supplies to research facilities set up on the moon as it is already predicted to transport supplies to the international space station. However, the real benefit for Australia is that the chosen launch site for the K1 is Woomera in South Australia. This will give Australia’s economy and tourism sector a huge boost from the offset but there is potential for industry boosts if Rocketplane Kistler decided to contract Australian industries and move its operations into the country.

The development of the K1 launch vehicle is just a short-term goal, as Australia should be seeking to become leaders in the space industry. Therefore instead of relying on other countries developing space programs and using Australian facilities such as the Woomera Space Port, Australia should be striving to eventually create its own space program. This does not mean that Australia should rush to try and land the first human on Mars, an Australian space program might see further development of sustainable launch vehicles or the development of improved propulsion systems including the HyShot and HYCAUSE research. Already, foreign companies have taken great interest in the HYCAUSE launch which took place in 2007 and given that much of the cost and the majority of weight in a launch vehicle is taken up by fuel, improved combustion and propulsion methods could see fuel put to better use which is hugely important to the development of the space industry. This will also boost the counties economy further if money is invested into our research and will allow research knowledge to grow and open more avenues into space exploration.

Australian led advancements in the space industry are certainly possible especially given that we have excellent launch conditions and readily available facilities in the Woomera Space Port. Furthermore, as the space industry continues to grow, more countries will seek to become involved but will not have the facilities to do so. Australia, due to its large area and low population density has the room and ideal conditions to develop more launch and research facilities that can be used by foreign companies.
Australia should have long and short-term goals in the space industry. On the short term, we should be welcoming companies such as Rocketplane Kistler and other companies that seek to use Australian facilities such as Woomera with the possibility of further facilities being developed. On the long term, Australia should be seeking to become industry leaders in the space industry and investing our own funding into space programs rather than relying on foreign companies. Development in the Australian space industry should be with a view to cost reduction and sustainability with research into improved propulsion systems as is currently underway with the HyShot and HYCAUSE programs.
7  FAMOUS AUSTRALIAN AVIATORS

Australians played an important role in pioneering aviation worldwide. Long before man’s first flight in an aircraft; Australians were active in developing lighter-than-air craft, parachutes and theory related to lift-producing bodies and wing surfaces. This section lists some of Australia’s most notable contributors to the Aviation industry together with their achievements.

Lawrence Hargrave

Born in Greenwich, England in 1950, Hargrave came to Australia at the age of 15. Hargrave found employment in the areas of maritime navigation, followed by foundry work, eventually gaining a position as an astronomical observer. Hargrave’s early work was inspired by the motion of birds and the flapping motion of their wings, ultimately his work in this area proved fairly unsuccessful. However, a change in direction in his research led him to invent the box kite. The box kite was more stable than any of the lifting surfaces that had been developed at that time. In 1894, Hargrave used a four-kite structure to lift himself off the ground over a distance of 16 feet.

![Figure 7.1 – Hargrave demonstrating his box kite [52]](image)

Herbert John Louis ‘Bert’ Hinkler

Bert Hinkler was born in Bundaberg, Queensland in 1892. At the age of 19 he successfully built and flew his first unpowered aircraft, a glider (see fig. 7.2). In 1913 he moved to England and served in the First World War, first as a gunner and later as a pilot. He later became a test pilot for A.V. Roe and Co, and broke many solo flying records between 1920 and 1930. Hinkler’s most notable achievement took place in 1928 when he became the first person to fly solo from England to Australia.
The flight was in a light aircraft called the Arvo Avian and took just 16 days, smashing the previous record of 28 days.

![Hinkler’s glider](image)

**Figure 7.2 – Hinkler’s glider [19]**

**Sir Charles Kingsford Smith**

Born in Brisbane in 1897, Sir Charles Kingsford Smith is arguably the most well known of Australia’s early aviators. Smithy, as he was affectionately known, served in the Australian army during the First World War and later as a pilot with the Royal Flying Corps. In 1928 he became the first person to complete a trans-pacific flight when he flew a three-engined Fokker FVIIb-3m from California to Brisbane; the journey took just under 84 hours of flying time. In 1932 he was knighted for his contribution to aviation. In 1935, during yet another long-range flight, Smith disappeared off the coast of Burma. Smithy was one Australia’s most loved figures, making his disappearance even more of a tragedy.

**Sir Ross and Sir Keith Smith**

In 1919 the Australian government announced a prize of £10,000 to be awarded for the first aircraft to fly from London to Australia in 30 days or less. The two brothers from Adelaide together with two mechanics won the race using a Vickers Vimy, a twin-engined British aircraft. Total flying time was 135 hours and due to adverse weather conditions, the entire trip took 28 days. The flight was significant in that it helped prove the viability of long distance air travel. The Sir Ross and Sir Keith Smith Fund was founded by Lady Anita Smith, and provides funding for undergraduate and postgraduate scholarships at the University of Adelaide, as well as sponsoring the teaching of subjects Aeronautical Engineering and Space Vehicle Design.

![Vickers Vimy](image)

**Figure 7.3 – Vickers Vimy [53]**
Nancy Bird Walton

Nancy Bird was a famous Australian pilot and founder of the Australian Women Pilots' Association. Nancy was born in Sydney, NSW in 1915. At the age of seventeen she was tutored in flying by Sir Charles Kingsford Smith at the Kingsford Smith Flying School at Mascot, Sydney. In 1935 Nancy began flying in the outback as part of a flying medical service called the Far West Children's Health Scheme. This was the first time in Australian commercial aviation history that a woman had been employed in the industry. This paved the way for women, not only in Australia but worldwide to be involved in the aviation industry.

John Flynn

John Flynn was a Presbyterian minister and aviator who founded the Royal Flying Doctor Service. After working as a minister in the remote South Australian outback, Flynn realised the need for a more adequate medical service due to the large distances between hospitals. After raising the required funds himself, the world's first flying doctor service was established, making its first flight in 1928 from Cloncurry to Julia Creek in Queensland. The Flying doctor service was also pioneering in its use of radio on aircraft to communicate with outlying communities and cattle stations. John Flynn is featured on the Australian $20 note.
8 HISTORY & AIRCRAFT OF THE ROYAL AUSTRALIAN AIR FORCE

8.1 Introduction

The Royal Australian Air Force (RAAF) provides air and space power for Australia’s national security. It is the youngest of the three armed services in the Australian Defence Force (ADF) – comprising of the Royal Australian Navy, the Australian Army and the Royal Australian Air Force – but the second oldest air force in the world, following the Royal Air Force (RAF). The RAAF’s coat of arms can be seen below – figure 8.1. The motto seen on the coat of arms is the Latin phrase ‘Per Ardua Ad Astra’ which means, “Through Struggle to the Stars”. The Royal Australian Air Force has an unusually long, but rich and proud history, with its true beginnings dating back as far as 1912, even though the RAAF was not officially formed until 1921.

8.2 The Development of the RAAF

Military aviation first found its wings in Australia at Point Cook in 1912, when the Central Flying School was established by the Minister for Defence, Senator G F Pearce. The Central Flying School was established to train the pilots that would form the Australian Flying Corps (AFC). Upon final approval in October of 1912 by the Military Board, applications were sought for ‘two competent mechanists and aviators’ to form the beginning of the school. Although several applications were received, the two aviators selected were Henry Petre, an English barrister, who with his brother had designed, built and flown the Petre Monoplane and was a pilot with the Deperdussin Company at Brooklands, England. The other was Eric Harrison, an Australian from Castlemaine, Victoria, at that time working for the Bristol Aeroplane Company in England. Point Cook was selected by the newly commissioned Lieutenant Petre since it was near to Army headquarters in Melbourne, and being situated near to the coast, had good access by sea and land. The site selected for the school was 734 acres of grazing land, purchased at a cost of over £6,000 ($12,000). On the 25th of April 1913, Lieutenant Harrison – also commissioned into the Australian Army – arrived in Australia from England with four mechanics H J Chester, A E Shorland, G A Fonteneau and C V Heath, along with five aircraft. To begin with, large tents were erected for use as hangars, before Lt Petre designed two wooden hangars.

On the 18th of August 1914, training of the first four trainee pilots began – Lieutenant R Williams, Captain T White, Lieutenant G Merz and Lieutenant D Manwell – with Lieutenants Petre and Harrison as instructors. Later that year, on the 12th of November, the first student Lt Richard Williams after approximately 3 months of training was awarded his ‘wings’. (The actual wings had to
be purchased by Williams for his uniform at a cost of three shillings and six pence!). The four newly trained pilots along with Lt’s Harrison and Petre were the founding airmen of the Australian Flying Corps, which would eventually evolve to be known as the Royal Australian Air Force.

8.2.1 Service in World War I (1914 – 1918)

On the 8th of February 1915, the Government of India sought assistance from Australia for trained airmen, aircraft and transport for service in Mesopotamia (Iraq). The Australian Government and the Australian Flying Corps responded to the call, supplying airmen and transport, but aircraft they could not. Lt Petre led a unit known as the ‘Mesopotamian Half Flight’ comprising of 41 airmen including White and Merz. The Mesopotamian campaign culminated with the tragic siege of Kut. Australia also responded to the call of Britain for trained airmen to be sent overseas for service in the First World War. Australian pilots were partially trained in Australia, and then sent to England to complete their training before they were assigned to one of the four operational AFC squadrons – Nos. 1, 2, 3 and 4 Squadrons. No 1 Squadron fought against the Turkish and Germans in the Middle East, while Squadrons 2, 3 and 4 were in action of the Western Front in France. An addition four squadrons, Nos. 5, 6, 7 and 8 were established to train pilots for service in the four front-line squadrons of the Australian Flying Corps between September 1917 and November 1918.

The only AFC member to be awarded the Victoria Cross (VC) during service in the First World War was Lt F H McNamara of No. 1 Squadron. He was awarded the VC for a heroic act which saved the life of a squadron colleague, Capt. D W Rutherford, whose BE2c aircraft was downed in enemy territory in Palestine on 20th March 1917. The leading ‘scorer’ of the AFC was Capt. AH Cobby, who flew Sopwith Camels for the No. 4 Squadron. He was credited with 29 aerial victories and also bringing down 13 observation balloons. For his efforts, he was awarded the Distinguished Flying Cross (DFC) and a Mention in Dispatches (MID).

8.2.2 The ‘between-the-wars’ Years

Following the war, the AFC squadrons were disbanded and the AFC was replaced by the Australian Air Corps, which manned to Point Cook base on a ‘caretaker’ basis. Nevertheless, there still existed a keen interest in military aviation, both by the defence services and the Australian public. There Australian Government of the time had identified the need for a permanent air force; however the only doubt was deciding the controlling service – the Navy or the Army. The division of opinion between the two defence services was ferocious and continuous. On the 1st April 1918, the British Government officially announced the formation of an independent air defence service and on this day, the Royal Air Force was born. This decision is believed to have heavily influenced the Australian Government to follow suite.

In 1920, Prime Minister Billy Hughes backed the Military Board’s decision to set-up an Air Corps with Lieutenant-Colonel Richard Williams, DSO, in command – the same Richard Williams who was first to earn his ‘wings’ at Point Cook in 1914. On the 9th of November 1920, a new Air Board was constituted. Shortly after, on the 15th of February 1921, it sent a recommendation to the Air Council that the ‘Australian Air Force’ be formed as of the 31st of March 1921. On the 30th of March, Lieutenant-Colonel R Williams was First Air Member of the Air Board, Australian Air Corps. The
next day, the 31st, Wing Commander R Williams became First Air Member of the Air Board for the Australian Air Force. At the time of formation, the aircraft count of the service numbered 151. This was comprised of 48 Avro 504K trainers, 28 DH9s, 35 SE5a fighters, 11 Sopwith Pup scouts and 29 DH9a bombers. Of the 151 aircraft, 128 of them were given to the Australian Air Force by the British Government as a sign of appreciation for the role Australia played and the assistance given in WWI.

King George V approved the ‘Royal’ prefix in June, becoming effective as of the August 31, 1921. From this day, the Royal Australian Air Force, or the RAAF as it is more commonly known, came into being.

The ‘between-the-wars’ years became the development period of the RAAF. Several new RAAF bases were established around the country – Laverton, Victoria (1921), Richmond, New South Wales (1923), Pearce, Western Australia (1934), Darwin, Northern Territory, Archerfield, Queensland and Rathmines, New South Wales (1939). During this time of gradual development and expansion, the RAAF assisted in a variety of national survey operations between 1926 and 1928. They surveying operations included surveying the Great Barrier Reef, Papua New Guinea, New Britain, the Solomon Islands and outback Australia, as well as potential civilian air fields and civilian air routes.

In 1926, the Australian Government spent 9 shillings per head of population on the Navy, 5 shillings on the Army and only 1 shilling on the Air Force. However, in 1934 things changed and the Government announced an increase in funding for the RAAF in an attempt to procure more modern aircraft and develop a minimum permanent service establishment of 108 officers and 791 enlisted ranks. The first of 48 Avro Anson general reconnaissance bombers were delivered in November of 1936, the first of many new purchases including, 18 Hawker Demon fighters and 24 Supermarine Seagull V amphibians. The creation of nineteen home defence squadrons was also approved, as international tension grew and the prospect of a second world war became ever more a reality.

At the time, it became clear to Britain that if war erupted, they would be hard-pressed to support the defence of Australia over 19,000 kilometres away. A big breakthrough occurred in 1938 when 50 Lockheed Hudson bombers from the US were ordered and became the first American built aircraft in service in the RAAF. It was also much welcomed news when, in 1939, Australia and Britain reached an agreement to build Bristol Beaufort bombers in Australia. These were built in Melbourne and Sydney, while from 1939 the de Havilland company began building Tiger Moths fitted with Australian built engines in Sydney. The Tiger Moth became the standard trainer for the Empire Air Training Scheme (EATS) and would see much use in the years to follow. This sparked the boom in the Australian aircraft industry, and couldn’t have come at a better time, as the world was on the verge of another war.

8.2.3 Service in World War II (1939 – 1945)

On the 1st of September 1939, Germany invaded Poland and two days later Britain declared war on Germany. At the time, 450 Australian pilots were already serving with the RAF in the United Kingdom (UK) and became the first Australian airmen to into action. No. 10 Squadron RAAF was also en route to the UK to take delivery of 9 Short Sunderland flying boats, purchased by the RAAF. The Squadron was offered to the RAF to serve as part of the Royal Air Force Coastal Command, flying anti-submarine patrols over the Atlantic Ocean. They did so for the duration of the War,
earning an outstanding reputation. No. 11 Squadron RAAF was stationed at Port Moresby with Catalina flying boats, flying long range reconnaissance patrols over northern Australia and north of Papua New Guinea. Also, in 1940, the No. 3 Squadron RAAF was posted to the Middle East as an army co-operation squadron with the Australian Imperial Force, but became a fighter squadron.

Plans had been made to raise and send more RAAF squadrons overseas at the time. However, the British empire realized the gigantic effort that was needed if they were to gain control of the air and the Empire Air Training Scheme (EATS) was devised. The EATS was an agreement between the Royal Australian, New Zealand and Canadian Air Forces to train aircrews and loan them to the Royal Air Force and was designed to provide a total of 50,000 trained aircrew every year as long as there was a need – 22,000 from Britain, 13,000 from Canada, 11,000 from Australia and 3,300 from New Zealand. Since training was required on such a large scale that Britain could not handle alone, it was agreed to train the majority of the men in Canada, Australia, New Zealand and Rhodesia. Upon completion of their training the men were to go to England to join RAF or Dominion squadrons under RAF operational control. In order to meet to commitment made by the Australian Government, the RAAF established 2 Air Navigation Schools, 3 Air Observers Schools, 3 Bombing and Gunnery Schools, 12 Elementary Flying Training Schools, 6 Initial Flying Training Schools and 8 Service Flying Training Schools. In addition, to train the many required ground crews in aircraft maintenance and equipment, 7 Schools of Technical Training and other specialised technical schools were established. The scheme proved a huge success for the Allies, and duration of the War saw 15,746 RAAF pilots, navigators, wireless operators, gunners and engineers sent to British squadrons and 11,641 to Australian squadrons. As a result, the RAAF alone formed seventeen squadrons in the UK and Middle East and in addition, provided thousands more aircrew for Royal Air Force, Royal Canadian Air Force and ‘free’ foreign squadrons.

At the height of the Second World War, the service had grown to a force of 20,000 officers, 144,000 airmen, and 18,000 airwomen and had 3,037 operational aircraft and 2,808 trainers. By the close of the War, Australian aircrews had flown in every major campaign from the Battle of France, Battle of Britain, the Normandy invasion, Egypt, the Middle East, Germany, Battle of the Atlantic, the defence of Malta, liberation of Italy, the Battles of the Coral and Bismarck Seas, Defence of Australia, to fighting in India, Burma, China, Singapore, Hong Kong, the Philippines, Papua New Guinea and the Pacific.

Every Australian who served in the War deserves to be recognized for their untold heroic efforts, not to mention the 10,754 Australians who lost their lives and the 3,290 who were seriously injured. However, two airmen that will always be remembered for a particular heroic effort that earned them a Victoria Cross (VC) are Flight Sergeant R H Middleton and Flight Lieutenant W E (‘Bill’) Newton. Flight Sgt. Middleton, flying a Short Stirling bomber with a RAF squadron, in November 1942, nursed his crippled bomber from Turin, Italy, across the Alps to England. Of his seven crewmen, five parachuted to safety, but the other two drowned. Middleton died alone in his aircraft when it crashed into the sea and was awarded the VC posthumously for his extraordinary effort. Flight Lt. Newton was also awarded the VC posthumously for his great determination in leading attacks with Douglas Boston aircraft against the Japanese in the South-West Pacific.

The RAAF legacy of the Second World War is a proud one, as the RAAF really ‘came of age’ as a service and earnt great respect as a highly trained and highly skilled air defence force.
8.2.4  Post WWII

Following the Second World War, an interim air force was formed on a ‘care and maintenance’ basis under the direction of Air Commodore J E Hewitt, until a the future role and demand of the RAAF became clearer. The period that followed saw a large downsizing and by 1946, the RAAF’s personnel numbers had fallen to 13,238 as government funding was drastically reduced. Many of the most senior and experienced officers were discharged or retired off in order to improve the career prospects of younger personnel. 1948 saw the RAAF strength hit a low of just 8,025; however in the same year, funding was gradually increased to raise the RAAF’s capabilities again.

Since the end of the Second World War, the RAAF has served with distinction in Korea, Malaya, Vietnam, Afghanistan and Iraq. In June 1950, the Communist Party of Malaya commenced terrorist activities in the region. The RAAF contributed No. 1 Squadron and its Lincoln bombers along with No. 38 Squadron and its Dakotas to the anti-guerilla operations. Also in June of 1950, No. 77 Squadron worked with the United Nations force to counter the invasion of North Korean troops into South Korea. The RAAF were mainly involved in ground support missions, combat air patrols and escort missions. From July 1952 until February 1954 RAAF No. 78 Squadron were deployed in Malta, contributing to the air defence of the Middle East.

The RAAF has also been heavily involved in the peacekeeping efforts and humanitarian missions throughout the world, including Bougainville, Cambodia, East Timor, Indonesia, Pakistan, Papua New Guinea, Rwanda, Solomon Islands and Somalia.

8.2.5  The RAAF of Today

The current day RAAF employs approximately 13,500 men and women, as well as 2,800 reservists and 900 civilian public servants and is the fourth largest air force in the world. The RAAF has twelve major air force bases located throughout Australia, including:

- RAAF Base Darwin (Northern Territory)
- RAAF Base Tindal (Katherine, Northern Territory)
- RAAF Base Townsville (Queensland)
- RAAF Base Amberley (Brisbane, Queensland)
- RAAF Base Williamtown (Newcastle, New South Wales)
- RAAF Base Glenbrook (Blue Mountains, New South Wales)
- RAAF Base Richmond (Sydney, New South Wales)
- RAAF Base Wagga (Wagga Wagga, New South Wales)
- RAAF Base East Sale (Gippsland, Victoria)
- RAAF Base Williams (Point Cook and Laverton (two sites), Melbourne, Victoria)
- RAAF Base Edinburgh (Adelaide, South Australia)
- RAAF Base Pearce (Perth, Western Australia)

In addition, the RAAF’s headquarters are located in Canberra and the current Chief of Air Force is Air Marshall Geoff Shepherd.

The RAAF currently operates 265 aircraft, comprising 17 squadrons, including:

- No 1 Squadron – General Dynamics F-111
- No 2 Squadron – Boeing Wedgetail (AEW&C)
- No 3 Squadron – McDonnell Douglas F/A-18 Hornet
- No 6 Squadron – General Dynamics F-111
- No 10 Squadron – Lockheed P-3C Orion
- No 11 Squadron – Lockheed P-3C Orion
- No 33 Squadron – Boeing 707
- No 34 Squadron – Boeing 737, Bombardier Challenger 604
- No 36 Squadron – Boeing Globemaster III
- No 37 Squadron – Lockheed C-130H/C-130J-30 Hercules
- No 38 Squadron – De Havilland Canada CHC-4 Caribou
- No 75 Squadron – McDonnell Douglas F/A-18 Hornet
- No 76 Squadron – BAE Systems Hawk 127
- No 77 Squadron – McDonnell Douglas F/A-18 Hornet
- No 79 Squadron – BAE Systems Hawk 127
- No 292 – Lockheed P-3C Orion
- No 2 OCU – McDonnell Douglas F/A-18 Hornet

Today, the RAAF is a multi-role service whose tasks include maritime patrol, peace-keeping missions, national security, reconnaissance and surveillance, as well as war-time training and preparation.

From a comparatively humble and difficult beginnings, including outright opposition from some senior military officers, the RAAF, since its birth in 1921, has evolved into a highly-sophisticated, technologically-advanced and indispensable arm of Australia’s defence. The officers, men and women of the Royal Australian Air Force are justifiably proud of the Service’s history and its achievements, both in war and peace times, and look forward with confidence to a future of continued service to Australia.

### 8.3 A Brief History of Aircraft of the RAAF, Past & Present

**Airco DH9a (1921 – 1930)**

The DH9a (pictured right) was the first machine listed on the RAAF register of aircraft. Initially, thirty of them were purchased by the RAAF and were numbered A1-1 to A1-30. The British built bomber was based an earlier model built by Airco, the DH4. The DH9 was successor of the DH4, using the same wings and tail section, but had a new fuselage and a more powerful engine – Galloway-Adriatic engine, predicted to produce up to 300 hp. This increased engine power was required for the DH9 to be able to match enemy fighters in terms of performance. However, operational service along the Western Front was not successful, incurring heavy losses of the DH9’s, due both to its low performance and engine failures. The DH9a was identical to the DH9, except is used a 400 hp,
Liberty-L12 engine and had slightly larger wings. This aircraft had better success in the Middle East against less heavy opposition. Both the DH9 and DH9a aircraft served with the RAAF for nine years.

**Sopwith Pup (1916 – 1925)**

The Sopwith Pup (pictured right) was a single seater biplane fighter aircraft, built by the Sopwith Aviation Company and was officially known as the Sopwith Scout. The Pup was similar to a conventional biplane aircraft with a mainly wooden framework covered in fabric, a single 80 hp Rhone rotary engine and although being underpowered had excellent maneuverability due to its light wing loading and ailerons fitted to all four wings. The Pup saw much service in France above the Western Front during WWI from late 1916 to late 1917, before being replaced by the Sopwith Camel aircraft after increasing casualties because of the new German fighters. However, the Sopwith Pup remained in service with the RFC (and RAAF) for many more years, serving excellently as a trainer aircraft.

**DAP Beaufort (1941 – 1946)**

The DAP Beaufort (picture right) was a large torpedo bomber designed by the Bristol Aeroplane Company. It could carry up to 2000 lbs (990 kg) of torpedoes and was powered by two Pratt and Whitney twin row Wasps, each 1200 hp – the same engine as used by the Boomerang attack fighter. They were used extensively during World War II for attacking shipping in the South-West Pacific, sinking enemy cruisers, destroyers and submarines, as well as inland bombing operations. They also served as convoy protection and coastal reconnaissance. Most of the Beauforts were phased out of service soon after the war; however, limited numbers were retained for fluid-spraying experiments.

**CAC Boomerang (1942 – 1946)**

The Boomerang fighter aircraft (picture right) was built by the Commonwealth Aircraft Corporation in 1942 at the time when Japan entered World War II. Its purpose was to provide the RAAF with a single fighter aircraft for home defence. The fighter was designed as an interceptor with a high rate of climb and good maneuverability and was fitted with the most powerful engine in Australia at that time, the 1200 hp twin wasp. The Boomerang established a strong reputation for its effective strikes throughout New Guinea, the Solomon Islands and Borneo during the Second World War.
**General Dynamics F-111 (1973 – present)**

The General Dynamics F-111 Aardvark (pictured right) is a long-range supersonic strategic bomber, originally purchased second hand from the US Air Force in 1973. It is a twin engine, swing-wing aircraft able to take-off at a low speed with its wings swept forward, and then fly more than twice the speed of sound with its wings swept back. It is capable of carrying a large weapons payload including laser-guided bombs and is fitted with the Pave Tack targeting system. It is also capable of carrying external fuel tanks to further extend its operational range. The RAAF currently operate 26 F-111’s, including 15 of the C variant, 7 of the G variant and 4 of the RF variant. Although having served for 34 years with the RAAF, the F-111 still remains Australia’s front line strike reconnaissance and strategic bomber and the fastest and longest ranging aircraft in the Asia-Pacific today. The F-111 is planned to continue service with the RAAF until 2015 when it will be replaced by the Joint Strike Fighter and the F/A-18 F Super Hornet.

**Boeing F/A-18 (1984 – present)**

The Boeing (originally McDonnell Douglas) F/A-18 Hornet (pictured right) is an all weather carrier-capable strike fighter jet. It is a multi-role fighter designed for both air-to-air and air-to-ground operations and is capable of air interception, air combat and close air support of ground troops. Originally developed by the US company McDonnell Douglas, the aircraft has been and continues to be used by Canada, Finland, Kuwait, Malaysia, Spain and Switzerland. Currently, 75 of the aircraft are in service with the RAAF, serving as their primary strike fighter aircraft, and have recently undergone major avionics upgrades to ensure effective operations for an addition 10 to 15 years. The RAAF has also signed up for the purchase of 24 Boeing F/A-18F Super Hornets to maintain Australia’s air combat edge until introduction of the Joint Strike Fighter program.
JINDIVIK

9.1 Introduction

The Jindivik is a type of target drone UAV that was developed and manufactured in Australia by the Government Aircraft Factory (GAF). Between 1952 and 1997, over 600 airframes were manufactured and the target drone became one of Australia’s most successful aviation exports. The name Jindivik comes from an Aboriginal word meaning *hunted one*. The Jindivik was used extensively by several countries including the United States and United Kingdom primarily in the testing of surface to air missiles. The following section focuses on all aspects of the UAV from its initial development to its current use in military applications.

9.2 History and development

With the development of high performance surface to air missiles in the 1940’s came the need to test the capabilities of these weapons in real-life combat situations. Much of the missiles testing took place at the Woomera test facility and in 1948, the British Ministry of Supply issued specification for a high speed UAV to be developed and supplied by the Australian government.

At the time, target drones were not a new idea; they had been in use in the United States since the 1930’s. The Stearman-Hammond JH-1 was the first remotely piloted vehicle to be fired upon by a missile [37]. This was closely followed by the conversion of several Curtiss N2C-2 training aircraft to UAV. The first drones were very low in performance and were primarily used to test Anti-Aircraft gunnery on US Navy battleships. The specifications of another early target drone, the OQ-2 manufactured in 1941 are shown in table 9.1. Table 9.1 highlights the changes that unmanned target drones underwent in the short period from 1941 to 1953 when compared to the specifications of the Jindivik in table 9.2.

RADIOPLANE OQ-2 Specifications

<table>
<thead>
<tr>
<th>Spec</th>
<th>Metric</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wingspan</td>
<td>3.73 meters</td>
<td>12 feet 3 inches</td>
</tr>
<tr>
<td>Length</td>
<td>2.65 meters</td>
<td>8 feet 8 inches</td>
</tr>
<tr>
<td>Takeoff weight</td>
<td>47.2 kilograms</td>
<td>104 pounds</td>
</tr>
<tr>
<td>Maximum speed</td>
<td>137 KPH</td>
<td>85 MPH / 74 KT</td>
</tr>
<tr>
<td>Service ceiling</td>
<td>2,440 meters</td>
<td>8,000 feet</td>
</tr>
<tr>
<td>Endurance</td>
<td>70 minutes</td>
<td></td>
</tr>
<tr>
<td>Launch scheme</td>
<td>Conventional runway takeoff.</td>
<td></td>
</tr>
<tr>
<td>Recovery scheme</td>
<td>Parachute or runway landing.</td>
<td></td>
</tr>
<tr>
<td>Guidance system</td>
<td>Radio control.</td>
<td></td>
</tr>
</tbody>
</table>

Table 9.1 [37]
After the end of World War 2 and the capture of German V-2 rocket, other countries including the US, USSR and UK began developing missiles and guidance systems. The British guided weapons programme required a long-range test facility and thus the town of Woomera was born.

The British supplied specification of the aircraft in 1948 and soon after, work began on two versions of the aircraft, a manned version called the Pika (of which only two were built) and the unmanned version Jindivik. The Pika was the first jet-engined aircraft to be built in Australia and was manufactured to help improve the automatic pilot, remote landing gear and general flying characteristics of the unmanned aircraft. The first Pika prototype flew on October 31st 1950. Construction of the Mk 1 Jindivik prototype began in December 1950, with the first unit, the A92-5 being flown on August 28 1952.

![Figure 9.1 – Pika (left) and Jindivik](image)

Design work on an improved version of the Jindivik began in 1950; the Mk 2 would have thinner wings, larger air intake and a 1640lb thrust turbojet engine supplied by Armstrong-Siddeley. This was a vast improvement over the 1050lb thrust offered by the Mk 1’s Armstrong-Siddeley Adder turbojet engine. Approximately 190 Jindivik Mk 2’s were built [28] with around 90 used at Woomera and the rest exported for use in the United Kingdom. A third version, the Mk 3 was built in 1960; this version featured a Bristol Siddeley Viper Mk 201 turbojet engine with 2500lb of thrust as well as other small changes from the previous model. The RAAF took delivery of its last Jindivik in 1966 and the drone continued in service until 1975. The final variant was the Mk 4 which was produced exclusively for the British military; production ran from 1981 continuing until 1988, 15 Mk 4’s were produced. The drone has continued to be used in the UK until the early 2000’s.
9.3 Operation

The pilot-less aircraft is used to tow a target, making it much safer than manned aircraft due to the fact that the missile often impacts the aircraft itself instead of the target. The targets can be in the form of flares attached by a wire rope to an onboard winch, allowing the target to be towed from 15-150m behind the aircraft and to be retracted during flight.

![Jindivik with flare target deployed](image)

Jindivik is flown by a team of pilots on the ground and was usually trailed by a manned aircraft used to direct the drone or give feedback to the operators.

The drone takes off from a computer controlled aircraft trolley, acceleration is provided by the aircrafts jet engine. Initially the aircraft is set at a zero lift configuration on the trolley with flaps retracted, at the correct speed flaps are deployed and the aircraft begins to pitch upwards, triggering the release mechanism on the trolley.

Pneumatically controlled flaps and skid are deployed during landing approach. Upon touchdown at 222km/hr the flaps retract and the fuel supply to the engine is remotely cut [28], allowing the aircraft to skid to a halt. The drone can be fitted with two different types of wing tip pods both of which are fitted with cameras, allowing visual missile tracking as well as accurate determination of target miss distances.

The Mk 3 and Mk 4 versions had the option of 2m wing tip extensions (shown in fig. 9.3) that were used for flight at high altitudes (up to 70000ft). Conversely, the Jindivik could be flown at altitudes of around 50ft to simulate very low flying aircraft making the drone robust.
9.4 Variants of the Jindivik

Pika – Manned prototype of the Jindivik airframe, first flown in 1950. Only two were manufactured, one crashed in 1954, badly injuring the pilot.

Mk 1 - This model was first flown in 1952, 14 airframes manufactured.

Mk 2 - First flown in 1953, this variant was fitted with a more powerful engine than the previous model. 111 airframes manufactured.

Mk 2a. - A modified version of the Mk 2, this variant featured wing tip extensions for higher altitude flying and a modified air intake. Only 3 airframes manufactured.

Mk 2b. - A modified version of the Mk 2a, this variant featured a more powerful engine with 1750lb thrust. 76 airframes manufactured.

Mk.3 - This version was first flown in 1961. It featured a 2500lb thrust engine. 9 were produced.

Mk. 3a. - An improved version of the Mk 3, there were 147 produced.
Mk 3b. - Modified version of the Mk 3a, this variant offered improved performance over a range of categories including top speed, range and ceiling altitude. 126 airframes manufactured.

Mk 4a. - Most modern version of the Jindivik with improved performance and maneuverability. Engine is a Rolls-Royce Viper Mk. 201 rated at 2780lb thrust.

9.5 Specifications

9.5.1 Performance

<table>
<thead>
<tr>
<th></th>
<th>Mk 3b</th>
<th>Mk 4a</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wing Span</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Altitude</td>
<td>6.32 m</td>
<td>6.32 m</td>
</tr>
<tr>
<td>High Altitude</td>
<td>9.78 m</td>
<td>9.78 m</td>
</tr>
<tr>
<td><strong>Length (incl. nose probe)</strong></td>
<td>8.15 m</td>
<td>8.15 m</td>
</tr>
<tr>
<td><strong>Max payload</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low altitude</td>
<td>249 kg</td>
<td>249 kg</td>
</tr>
<tr>
<td>High altitude</td>
<td>181 kg</td>
<td>181 kg</td>
</tr>
<tr>
<td><strong>Max. Takeoff weight</strong></td>
<td>1655 kg</td>
<td>1814 kg</td>
</tr>
<tr>
<td><strong>Maximum speed</strong></td>
<td>530 knots (981km/hr)</td>
<td>540 knots (1000 km/hr)</td>
</tr>
<tr>
<td><strong>Maximum range</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low altitude configuration</td>
<td>800nm (1482km)</td>
<td>825nm (1529km)</td>
</tr>
<tr>
<td>High altitude configuration</td>
<td>900nm (1668km)</td>
<td>1160nm (2150km)</td>
</tr>
<tr>
<td><strong>Min. operational height</strong></td>
<td>15 m</td>
<td>12 m</td>
</tr>
<tr>
<td><strong>Max. operational ceiling</strong></td>
<td>16460m</td>
<td>15850m</td>
</tr>
<tr>
<td>Low altitude configuration</td>
<td>20420m</td>
<td>19810m</td>
</tr>
<tr>
<td><strong>Time taken to reach max operational ceiling.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low altitude configuration</td>
<td>26 minutes</td>
<td>26 minutes</td>
</tr>
<tr>
<td>High altitude configuration</td>
<td>34 minutes</td>
<td>34 minutes</td>
</tr>
</tbody>
</table>

* - Data for drone fitted with the Mk9 wing tip pods shown in figure 9.3

38
9.5.2 Construction

Airframe - Low-wing monoplane with aluminium alloy partial-monocoque fuselage. Aluminium alloy multispar wings with integral fuel tanks. 2°30’ dihedral, 1° α₀. Aluminum alloy flaps, elevators and ailerons.

Guidance - UHF radio transmitter. GEC Avionics gyroscopic flight control computer.

Equipment - Rear mounted flare packs for testing of IR missiles. Microwave reflectors (Luneburg lenses) and radio transponders, which allow the drone to simulate a wide variety of different aircraft. Cameras mounted in wing tip pods.
10 CIVILAN AIRCRAFT

10.1 Home built

Homebuilt aircraft, also known as amateur-built aircraft or kit planes. The first to be offered for sale as plans, rather than an assembled craft, was the *Ace Baby Ace* in the late 1920’s [51]. The popularity of these homebuilt aircraft expanded during the 1950, with a large demand by ex-military pilots after World War II. These aircraft have always been single to four seaters, which employ very simple methods of construction.

10.1.1 Building materials

In the early day the building materials of these light aircraft was anything that was light and strong enough to withstand flight. The oldest construction material is wood and cloth, which offered exceptional strength to weight ratios. These structures were joined with adhesive, most commonly epoxy, and in most cases, all wood joints are simple butt joints, which are designed to be stronger than the members. Once the aircraft had been completed, then the whole structure was covered with light cloth. This style was very common in the early years, as there is little need for specialised building equipment, where only wood and cloth are the chief building materials. This method of construction is still used in modern day hobby craft, but most often a wood-cloth-foam hybrid style is used, allowing the construction of lighter and stronger structures. Similar to the wood-cloth style was a steel tubing and cloth design, which improved the strength of the craft without increasing the weight considerably. This was just one advance that the hobby craft industry would take.

In the 1950’s, metal construction kits were introduced into the market, but these initial designs were heavy, and for an increased strength and aerodynamic design, manoeuvrability and stability were sacrificed. This led to improvements in the designs, and the metals used, and as such, metal alloy kits entered the market and these were a vast improvement on the wood-cloth and steel tube-cloth designs. In the late 1980’s, Burt Rutan introduced the canard design, which incorporated the use of composites into the construction of hobby craft. This progress in building materials again increased the strength of the craft, but unlike the metal design, it decreased the total weight of the aircraft, and it increased the aerodynamics of the craft and with the use of composites instead of metals, the price of a kit was also reduced. This led to another increase in popularity for many homebuilt kits and plans. These composite kits also reduce the drag due to rivets, and allowed much more complex curves and shaped to be moulded [51]. However, there are drawbacks with the use of composites, which include the mandatory use of chemical products, as well as the low strength in material directions perpendicular to fibre directions, which introduces the need for ‘elastic tailoring’ of composite parts [51].
10.1.2 Size

The size of the original hobby craft included large wingspans and small fuselages, as well as little or no aerodynamic styling. The original intent for these planes was for them to fly, and that was in fact all that they did. As the years progressed, the design of the hobby craft increased in style and aerodynamic effectiveness, which was achieved by the reduction of wingspans, the larger aerodynamic styling taken into account with the shape of the fuselage, and more efficient wing design. Similarly, the size of the engine required to power the craft has reduced over the years, due to the increases in engine efficiency, and the different types of engines. In recent years, there have been several small jet kit planes released, but these are very unpopular, as the purchase and upkeep, costs are large.

10.2 Airports

In the early years, there were no airports, as such, but rather planes landed wherever there was suitable relatively smooth and dry ground. Showgrounds, sporting fields, farms and even beaches all were used [7]. However, as time progressed, airports started to come about, with the use of ‘communal’ storage of aircraft, and runways specifically designed for the use of aircraft taking off and landing. As the years passed, airports took more of a standard shape, with a 1–2km long dirt runway, and several sheds for storage of craft. By 1934, regular airports had been constructed in all major cities, as well as a few minor towns. By this time, all airports consisted of long gravel runways, which, unlike dirt and grass, allowed aircraft to use it in bad weather conditions. Storage was now progressing with the use of large hangers, but there were still no ‘specific’ control towers in place at all the airports. This started to change at the beginning of the Second World War, when control towers and new terminals were constructed at the Parafield, Mascot and Archerfield airports between 1938 and 1940 [7]. These new structures allowed much broader use of the airports by commercial craft, but there was very little civilian traffic. This lead to major airports having air traffic control services installed, and were surrounded by large areas of controlled space, managed from the ground by radio and radar. By 1959, 24 aerodromes had air traffic control and facilities were poised for the beginning of the jet age. In 1961, prior to the introduction of the first 747 jumbo jet, all runways were required to be lengthened from proximately 8,500 ft to 12,000 ft, which would allow the recieval of the 747’s. Since this upgrade, airport around the country have continued to grow in size, increasing storage capacity, and runway numbers and sizes, to those now seen at present. There are still some smaller airports, but these are chiefly used for recreational pilots, and amusement purposes.
11 COMMERCIAL AVIATION HISTORY

Australia has had commercial airlines since just before World War Two. There are numerous airlines operating in Australia, some purely domestic only, some purely international only, with exceptions like Qantas which offers both. Australia has a number of small domestic carriers such as Virgin Blue and Regional Express, as well as low-cost carriers like JetStar and international carriers including Qantas, Emirates and Malaysia Airlines. Domestic competition has led to some airlines offering seats for $1, these do not include GST however. Australia’s two biggest airlines have been Qantas and Ansett Australia. The latter is no longer in business but until it went into receivership in 2001/2002, was the second largest Australian airline behind Qantas. The history of these two major airlines is as follows:

11.1 Qantas

Qantas is the name of the national airline of Australia. Qantas is also the world's third oldest continuously running airline (after KLM - Royal Dutch Airlines and Avianca). Qantas operates a total of 213 aircraft, which includes 28 aircraft in the Jetstar Airways fleet and 49 aircraft under the various QantasLink brands.

The name was originally "QANTAS", an acronym for "Queensland and Northern Territory Aerial Services". The company is based in Sydney, NSW and it is Australia's largest airline.

11.1.1 Beginnings

Qantas was founded in Winton, Queensland on 16 November 1920 as Queensland and Northern Territory Aerial Services Limited by Paul McGuiness, Hudson Fysh, Fergus McMaster and Arthur Baird. The airline's first aircraft was an Avro 504K. The aircraft had a cruising speed of 105 kilometres per hour (65 mph) and carried one pilot and two passengers. Alexander Kennedy was the first passenger, receiving ticket number one. The airline operated air mail services subsidised by the Australian government, linking railheads in western Queensland.

Between 1926 and 1928, Qantas built seven De Havilland DH.50s and a single DH9 under licence in its Longreach hangar. In 1928 a chartered Qantas aircraft conducted the inaugural flight of the Royal Flying Doctor Service of Australia, departing from Cloncurry.
11.1.2 World War Two — 1934 to 1945

In 1934, QANTAS Limited and Britain's Imperial Airways (the forerunner of British Airways) formed a new company, Qantas Empire Airways Limited. Each partner held 49%, with two per cent in the hands of an independent arbitrator. The new airline commenced operations in December 1934 flying between Brisbane and Darwin using old fashioned DH50 and DH61 biplanes.

QEA went international from May 1935, when the service from Darwin was extended to Singapore using newer de Havilland DH-86 Commonwealth Airliners. Imperial Airways operated the rest of the service through to London. In July 1938, this operation was replaced by a three weekly flying boat service using Shorts S.23 Empire Flying Boats. The Sydney to Southampton service took nine days, with passengers staying in hotels overnight. For the single year of peace that the service operated, it was profitable and 94% of services were on time. This service lasted through until Singapore fell in February 1942. Enemy action and accidents destroyed half of the fleet of ten, when most of the fleet was taken over by the Australian government for war service.

Flying boat services were resumed with American built PBY Catalinas in July 1943, with flights between Perth and Ceylon (now Sri Lanka). This linked up with the BOAC service to London, maintaining the vital communications link with England. The 5,652km non-stop sector was the longest flown up to that time by any airline, with an average flying time of 28 hours. Passengers received a certificate of membership to the "Order of the Double Sunrise" as the sun rose twice during the flight. These flights continued until July 1945.

11.1.3 Post World War Two — 1945 to 1959

After World War II, QEA was nationalised, with the Australian Labor government led by Prime Minister Ben Chifley buying the shares of both Qantas Limited and BOAC. Nationalised airlines were normal at the time, and the Qantas board encouraged this move.

Shortly after nationalisation, QEA began their first services outside the British Empire — to Tokyo via Darwin and Manila with Avro Lancasterian aircraft. These aircraft were also deployed between
Sydney and London in cooperation with BOAC, but were soon replaced by Douglas DC-4s. Services to Hong Kong began around the same time.

In 1948, the airline took delivery of Lockheed L.049 Constellations. In 1952, Qantas expanded across the Indian Ocean to Johannesburg via Perth, Cocos Islands and Mauritius, calling this the ‘Wallaby Route’. Around this time, the British Government placed great pressure on Qantas to purchase the De Havilland Comet jet airliner, but Hudson Fysh was dubious about the economics of the aircraft and successfully resisted this. The network was expanded across the Pacific to Vancouver via Auckland, Nadi, Honolulu and San Francisco in early 1954 when it took over the operations of British Commonwealth Pacific Airlines (BCPA). This became known as the Southern Cross Route.

In 1956, Qantas became the first non US airline to order the Boeing 707 jet airliner. Contrary to popular belief, the special shortened version for Qantas was the original version Boeing offered to airlines. Boeing lengthened the aircraft by ten feet for all other customers, which destroyed the economics for Qantas. The airline successfully negotiated with Boeing to have the aircraft they had originally contracted for.

In 1958, Qantas became one of the very few round-the-world airlines, operating services from Australia to London via Asia and the Middle East (Kangaroo route) and via the Southern Cross route with Super Constellations. It took delivery of new turboprop Lockheed Electra aircraft in 1959.

**11.1.4  1959 to 1992**

The first jet aircraft on the Australian register (and the 29th 707 built) was registered VH-EBA and named City of Canberra. This aircraft returned to Australia as VH-XBA in December 2006 for display in the Qantas Founders Outback Museum at Longreach, Queensland. The first jet service operated by Qantas was on 29 July 1959 from Sydney to San Francisco via Nadi and Honolulu. On 5 September 1959, Qantas became the third airline to fly jets across the Atlantic — after BOAC and Pan Am, operating between London and New York as part of the service from Sydney. All of the turbojet aircraft were converted to upgraded turbofan engines in 1961 and were rebranded as V jets from the Latin *vannus* meaning fan.

Air travel grew substantially in the early 1960s, leading Qantas to order the larger Boeing 707-338C series of aircraft. In 1966, the airline diversified its business by opening the 450 room Wentworth Hotel in Sydney. The same year, Qantas placed early options on the new Concorde airliner. At the time supersonic flight was thought of as the way of the future, but along with most airlines in the world the orders were eventually cancelled. Also in 1966, another around-the-world route was opened, the Fiesta route. Sydney to London via Tahiti, Mexico City, and Bermuda.

In 1967, the airline placed orders for the new Boeing 747. The aircraft could seat up to 350 passengers, a major improvement over the Boeing 707-138's. Orders were placed for four aircraft with deliveries commencing in 1971. The later delivery date allowed Qantas to take advantage of the -200B version, which better suited its requirements. Also in 1967, Qantas Empire Airways changed its name to just Qantas Airways, the name of the airline today.
When Cyclone Tracy devastated the town of Darwin at Christmas 1974, Qantas established a world record for the most people ever embarked on a single aircraft when they evacuated 673 people on a single Boeing 747 flight. They also established a record embarking 327 people on Boeing 707 VH-EAH. Later in the decade, Qantas placed options on two McDonnell Douglas DC-10 aircraft for flights to Wellington, New Zealand. These were not taken up, and two Boeing 747SP were ordered instead. In March 1979, Qantas operated its final Boeing 707 flight from Auckland to Sydney, and became the only airline in the world to have a fleet that consisted of Boeing 747s only. That same year Qantas introduced Business class — the first airline in the world to do so.

The Boeing 767-200 was introduced in 1985, for New Zealand, Asia and Pacific routes. The same year, the Boeing 747-300 was introduced, featuring a stretched upper deck. The Boeing 747 fleet was upgraded from 1989 with the arrival of the new Boeing 747-400 series. The delivery flight of the first aircraft was a world record, flying the 18,001km from London to Sydney non-stop.

In 1990, Qantas established Australia Asia Airlines to operate services to Taiwan. Several Boeing 747SP and Boeing 767 aircraft were transferred from Qantas service. The airline ceased operations in 1996.

11.1.5 Privatisation — 1992 to the present

The Australian Government sold the domestic carrier Australian Airlines to Qantas in August 1992, giving it access to the national domestic market for the first time in its history. The purchase saw the introduction of the Boeing 737 and Airbus A300 to the fleet, the A300s were retired soon after. Qantas was privatised in March 1993, with British Airways taking a 25% stake in the airline for A$665m.

In 1998, Qantas co-founded the Oneworld Alliance with American Airlines, British Airways, Canadian Airlines, and Cathay Pacific. The alliance commenced operation in February 1999, with Iberia and Finnair joining later that year. Oneworld markets itself at the premium travel market, offering passengers a larger network than the airlines could on their own. The airlines also work together to provide operational synergies to keep costs down.

The main domestic competitor to Qantas, Ansett Australia, collapsed on 14 September 2001. Market share for Qantas immediately neared 90%, with the relatively new budget airline Virgin Blue holding the remainder. In order to capitalise on this event, Qantas ordered Boeing 737-800 aircraft — obtaining them a mere three months later. This unusually short time between order and delivery was possible due to the terrorist attacks in the United States on 11 September — the subsequent downturn in the US aviation market meant American Airlines no longer needed the aircraft they ordered. The delivery positions were reassigned to Qantas on condition the aircraft remained in American Airlines configuration for later possible lease purposes.

At the same time, Virgin Blue announced a major expansion in October 2001, which was successful in eventually pushing the Qantas domestic market share back to 60%. To prevent any further loss of market share, Qantas responded by creating a new cut-price subsidiary airline Jetstar. This has been
successful in keeping the status quo at around 65% for Qantas group and 30% for Virgin Blue with other regional airlines accounting for the rest of the market.

On 13 December 2004, the first flight of Jetstar Asia Airways took off from its Singapore hub to Hong Kong, marking Qantas' entry into the Asian cut-price market. Qantas owns 44.5% of the carrier.

Qantas has also expanded into the New Zealand domestic air travel market, firstly with a shareholding in Air New Zealand and then with a franchise takeover of Ansett New Zealand. In 2003, Qantas attempted and failed to obtain regulatory approval to purchase a larger (but still minority) stake in Air New Zealand. Subsequently Qantas stepped up competition on the trans-Tasman routes, recently introducing Jetstar to New Zealand. British Airways sold its 18.5% stake in Qantas in September 2004 for £425 million, though keeping its close ties with Qantas intact.

Qantas had also developed a full-service all economy international carrier focused on the holiday and leisure market, which had taken on the formerly used Australian Airlines name. This airline ceased operating its own liveried aircraft in July 2006, with the staff operating Qantas services before being closed entirely in September 2007, with the staff joining the new Qantas base in Cairns.

Its main international hubs are Sydney Kingsford Smith International Airport and Melbourne Tullamarine Airport. However, Qantas operates a significant number of international flights into and out of Brisbane Airport, Perth Airport, Singapore Changi Airport, Los Angeles International Airport and London Heathrow Airport. Its domestic hubs are Sydney, Melbourne, Brisbane and Perth airports, but the company also has a strong presence in, Adelaide, Cairns and Canberra airports. It serves a range of international and domestic destinations.

Qantas wholly owns Jetstar Airways, JetConnect (which operates New Zealand domestic and some Transtasman services) and QantasLink (including, Airlink, Sunstate and Eastern Australia Airlines). Qantas did have a minor 4.2% stake in Air New Zealand, however this was sold on 26 Jun 2007 for NZ$119 million. Qantas owns 49% of the Fiji-based international carrier Air Pacific. It owns 50% of both Australian Air Express and Star Track Express (a trucking company), with the other 50% of both companies owned by Australia Post. Since its privatisation in 1993, Qantas has been one of the most profitable airlines in the world. It was recently voted 5th best airline in the world in the 2007 World Airline Awards (with surveys conducted by Skytrax) having fallen from 2nd in 2005-6 (Singapore Airlines was ranked number 1)

Qantas has stepped up the expansion of Jetstar, with the launch of international services (in addition to existing trans-Tasman and Jetstar Asia flights) to leisure destinations such as Bali, Ho Chi Minh City, Osaka and Honolulu from November 2006. On some routes such as Sydney-Honolulu, Jetstar will supplement existing Qantas operations but many routes are new to the network. The lower cost base of Jetstar allows the previously unprofitable or marginal routes to be operated at greater profitability.

In recent years it has announced substantial new aircraft orders. Qantas ordered twelve Airbus A380-800, with options for twelve more. It will be the second airline (after launch customer Singapore Airlines) to receive an A380 and is now expected to receive four aircraft by the end of 2008 and seven by mid-2009, after Airbus reported further delays in the delivery. Qantas exercised 8 options on A380s, increasing firm orders to 20 on 29 October 2006. All aircraft are due to be delivered between
2008 to 2015. An additional four A330-200 aircraft (VH-EBE to EBH) were ordered to address capacity concerns due to the A380's service entry delay.

On 14 December 2005 Qantas announced an order for 115 Boeing 787-8 and 787-9 aircraft (45 firm orders, 20 options and 50 purchase rights). The aircraft will allow Qantas to replace their 767-300 fleet, increase capacity and establish new routes. Jetstar will also operate 15 of the new aircraft on international routes. This announcement came after a long battle between Boeing and Airbus to meet the airline's needs for fleet renewal and future routes. The first of the 787s are scheduled to be delivered to Jetstar in August 2008, with the 787-9s coming in 2011.

11.2 Ansett Australia

11.2.1 Beginnings

The company was started by Sir Reginald Miles Ansett in 1935 as Ansett Airways Pty. Ltd. This was an offshoot of his road transport business which had become so successful it was threatening the freight and passenger revenue of Victorian Railways.

Ansett's first route was between Hamilton, in western Victoria, and Melbourne, the state capital, operated with a Fokker Universal monoplane. The rapid success of the airline led Ansett to float the business in 1937. As the route network expanded, Ansett Airways imported Lockheed Electra aircraft. During World War II Reg Ansett opted to suspend all scheduled services in favour of more lucrative work for the USAAF. After the war Ansett battled to re-establish his domestic routes using war-surplus Douglas DC-3s, converted from C-47s and a motley collection of smaller airliners.

At this time, the Australian domestic airline travel sector was dominated by Australian National Airways (ANA), established in 1936 by a consortium of British-financed Australian shipowners. The Chifley Labor government was determined to establish a state-owned airline to operate all domestic and international services. It was eventually thwarted in this aim by the High Court of Australia, and so it established Trans Australia Airlines (TAA) to operate in competition with ANA.

11.2.2 1940s to 1990s

Ansett Airways remained a bit player as TAA and ANA battled for supremacy in the 1940s and 1950s. TAA, being better managed and having better aircraft, had driven ANA to the verge of bankruptcy by 1957. Ansett operated around the big two, maintaining budget fare interstate operations with DC-3s and later Convair CV-340s. The airline was backed up by extensive road transport.
operations, including Ansett Freight Express and Ansett-Pioneer Coaches, as well as the Ansair coach-building operation.

The Menzies’ Liberal government, while supporting TAA because of the excellent dividends it paid to the government, wanted to avoid TAA having a monopoly on domestic services if ANA collapsed, as seemed likely. The only alternative, as it transpired, was for Ansett to buy out the ANA operation. The ANA directors fiercely resisted this initially, but eventually succumbed to Ansett's offer of 3.3 million pounds for their airline. Ansett's bid had a number of financial supporters, most prominent of these being the Shell Company. Douglas Aircraft was also concerned about ANA’s demise, as TAA had ceased to be a customer for their aircraft. The new entity was called Ansett-ANA, the name it retained until 1968.

Ansett-ANA's excellent profit record was largely courtesy of the Menzies government's 'Two Airlines Policy' which propped up Ansett-ANA and clipped TAA's superior marketing efforts. The policy effectively blocked any other domestic interstate operators by way of a ban on importation of aircraft without a government licence. From 1957 until the 1980s Ansett and TAA operated as virtual carbon copies of each other, operating the same aircraft at the same times to the same destinations.

Reg Ansett then set out to ensure no other competitors could rise up to challenge his airline, as he had done with ANA. He took control of Adelaide-based Guinea Airways (renamed Airlines of South Australia) and Sydney-based Butler Air Transport (renamed Airlines of New South Wales). The takeover of Butler was achieved with covert support from the Menzies government and by Ansett engineering his employees' purchases of Butler shares. He then flew the employees to a general meeting in Sydney and forced a vote in favour of selling out to Ansett.

Ansett-ANA was profitable courtesy of government support, but also because of Reg Ansett's parsimonious ways. Ansett-ANA operated from terminals around the country that were best described as spartan.

Following the takeover of ANA, Reg Ansett lobbied the government to block TAA's purchase of Sud Caravelle jet aircraft. He was concerned about his airline's ability to finance equivalent jet aircraft, and the major engineering leap required to go from an all-piston fleet direct to pure jet aircraft. TAA had been operating prop-jet Vickers Viscounts since 1954, and so had expertise in jet technology. Ansett was successful in convincing the government to authorize the importation of more Viscounts and the new Lockheed L.188 Electra. This action delayed the introduction of pure jet aircraft to Australian skies until 1964, when the Boeing 727-100 began flying.

The post-war years were marked with numerous acquisitions, including Australian National Airways (1957). The airline prospered during the second half of the 20th century, especially in the 1980s. However a number of substantial investments performed badly, including a share in the US airline America West Airlines (which filed for bankruptcy, but survived) and its Hamilton Island resort (which went into receivership). Ansett also paid millions of dollars for the right to be official airline of the Sydney 2000 Olympics, an investment generally regarded as unwise. This destabilised the financial position of the company considerably.

One of the most unusual aircraft that was operated by Ansett was the DC-4 / C-54 outsized freighter conversion ATL-98 Carvair. Three of the airlines own DC-4s were delivered to the United Kingdom
for conversion by Aviation Traders Limited, the company run by Sir Freddie Laker as Managing Director.

Ansett commenced international service on 11 September 1993 to Bali, Indonesia.

11.2.3 2000 Onwards – Demise

Figure 11.3 - Ansett aircraft at Melbourne Airport after the airline's collapse in 2001

Air New Zealand, previously a 50% shareholder, acquired full ownership of Ansett in February 2000, buying out News Corporation's stake. This was widely viewed as a mistake, as Ansett became more of a drain than an asset (mostly because Ansett had more employees, more aircraft, and more financial overhead). Competition from Qantas and a succession of start-up airlines, top-heavy and overpaid staff, an aging fleet and grounding of the Boeing 767 fleet due to maintenance irregularities left Ansett seriously short of cash (losing $1.3 million a day). Air New Zealand attempted to cut the costs of Ansett whilst maintain a constant level of revenue. This did not work, as the cost cutting hurt Ansett, with the notable incidences being the grounding of planes in Christmas 2000 and Easter 2001. Air New Zealand was thus unable to compete with the low costs carriers and Qantas, who were able to run at a loss on some routes, as they could not maintain revenue while cutting their costs, which included laying off staff. Ansett's main issue was the costs it incurred at running each leg; for every $1 of revenue, 10 cents was profit compared to Qantas' 60 cents for the same amount. The government of New Zealand eventually bailed out Air New Zealand with 1 billion dollars, but would not fund Ansett at all. Air New Zealand placed the Ansett group of companies into voluntary administration with PricewaterhouseCoopers on 13 September 2001. A day later, the administrator decided that Ansett was not viable and grounded the fleets of Ansett and its subsidiaries Hazelton Airlines, Kendell, Skywest and Aeropelican. Customers and employees had no warning of the stoppage in operations. Everyone was being told in the days leading up to 14 September that flights would continue on schedule. Ansett employees did not find out until they showed up for work that day, and thousands of passengers were left stranded. More than 16,000 people found themselves out of a job, making this the largest mass job loss event in Australian history.

After receiving a federal government guarantee, Ansett resumed limited services between major cities on 1 October 2001. This was referred to as 'Ansett Mark II'. In November 2001 Ansett creditors voted in favour of the Tesna consortium led by Melbourne businessmen Solomon Lew and Lindsay Fox, to purchase Ansett. The plan included very reduced staff numbers and new aircraft. Fox and Lew said they had received no support from the government for their bid, thus withdrawing their proposal. This agreement, although well advanced, collapsed in February 2002. With no other saviours, Ansett
ceased operations permanently on 4 March 2002 by which point the administration of the company had transferred to newly formed insolvency firm KordaMentha. The Australian Securities and Investment Commission (ASIC) began an investigation of whether Ansett had gone on trading while insolvent, and eventually determined in July 2002 that it would be too expensive and difficult to proceed with an action which would, in any case, need to be many separate actions on behalf of individual creditors rather than just one. Laid-off Ansett workers were eventually paid most of their entitlements, partly from an $A150 million compensation package offered by Air New Zealand in return for having the ASIC enquiry dropped, but mostly by an $A10-per-seat levy imposed by John Howard's government on Australian airline passengers.

11.2.4 Fleet

The Ansett Australia fleet as of 1999 was made up of the following aircraft:

- Airbus A320 x20
- BAe-146 x18
- Boeing 737-300 x23
- Boeing 747-400 x2
- Boeing 767-200 x9
- Boeing 767-300 x4
- Bombardier CRJ-200 x12 (Operated by Kendell)
- DeHavilland Twin Otter x4 (Operated by Aeropelican)
- Fokker 50 x9
- Fokker F27 x1
- Fokker F28 x4
- Saab 340 x16 (Operated by Kendell and Hazelton)
- Fairchild Metro 23 x7 (Operated by Kendell and Hazelton)
12 CONCLUSION

The preceding data and statistics all demonstrate the colourful and detailed history of the Australian aerospace industry. From the early years, with the development of the RAAF at Point Cook in 1912, and the founding of Qantas in Winston in 1920, Australia has been among the leaders within the aerospace industry. Through the requirements necessary to travel across the Australian continent, many groups have endeavoured to increase the ease at which it is available to continue to travel and transport goods across this wide, barren country.

Originating from just two individuals, the Royal Australian Air Force (RAAF), then known as the Australian Flying Corps (AFC), and from just an area of 734 acres, the AFC was formed. Soon after the first trainee finished training, the AFC was founded as an organization in which many pilots were trained over the years. During the First World War, the four squadrons were deployed across Europe, and Lt F H McNamara of squadron No. 1 was the only AFC member to be awarded the Victoria Cross. During the years following the First World War, and before the second, the AFC squadrons were disbanded and the AFC was replaced with the Australian Air Corps. Following the formation of the Royal Air Force in April 1918, the Australian government choose to change the Australian Air Corps to the Royal Australian Air Force, which is still in existence to this day.

As with the RAAF, there were many commercial interests forming, including the now famous Qantas. In the beginning, the aircraft was an Avro 504K, which could carry one pilot, and two passengers. As time progressed, so did the aircraft, which were flying under the Qantas tag, flying the first international flight in May 1935, from Darwin to Singapore. Following the Second World War, flights were commencing to fly from Australia to Tokyo, London and Hong Kong. By late 1959, the first jet aircraft was operating under the Qantas register, and in July 1959, Qantas was only the third jet service to fly across the Atlantic. In 1985 the first Boeing 747-200 was introduced into the Qantas fleet, and in 1992, Qantas was sold by the government to a private bidder, which led to the introduction of the Boeing 737 and the Airbus A300 into the Qantas fleet.

The future of the Australian aerospace industry lies in the testing and designing of new technology. The majority of this research is undergone surrounding the launch base in Woomera, with it isolation from surrounding towns, it is a prime locations for the testing of missiles and rockets. This in mind, as the technology advances, so will the cost, with prices to get a Low Earth Orbit rocket into space between US$2,000 and US$8,000 per pound of mass. More specifically, the testing at present is surrounding the Kistler’s Rocketplane project, with an emphasis on the development of a completely reusable rocket.
13 REFERENCES


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