ENGINEERS AUSTRALIA

Western Australia Division

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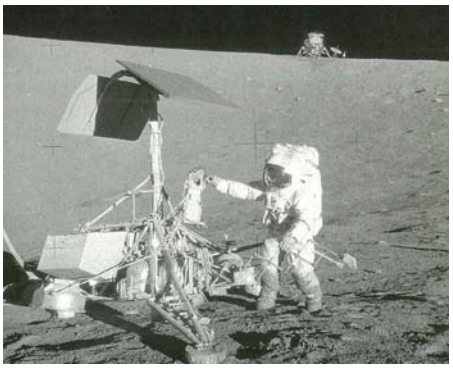
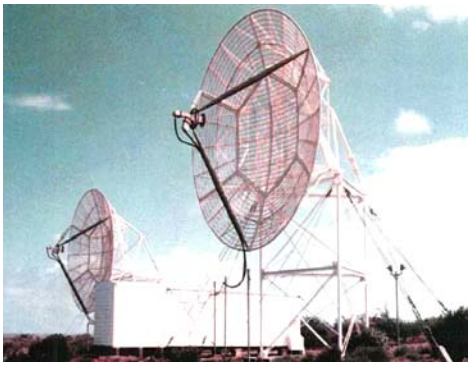
NOMINATION OF
NASA SPACE TRACKING STATION CARNARVON
FOR
ENGINEERING HERITAGE RECOGNITION

PREPARED BY ENGINEERING HERITAGE WESTERN AUSTRALIA
ENGINEERS AUSTRALIA
WESTERN AUSTRALIA DIVISION

March 2012

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1.0 INTRODUCTION

In the early 1960's NASA (National Aeronautics and Space Administration of America) sought communication facilities in Australia to support both the tracking of scientific satellites and the next generation of manned space flights, the Gemini and Apollo missions. After an extensive search in July 1962, it chose a site on Brown Range just outside Carnarvon. The location was a logical choice. The launch flight passed over the Carnarvon area and Australia was a politically stable country.

Carnarvon Tracking Station (Call sign CRO, herein referred to as NASA Carnarvon) was established in 1963. Until it closed in May 1975, it was NASA's largest tracking station outside USA.

In 1962 Carnarvon was a rural remote town of 2000 inhabitants, with poor communications, minimal infrastructure, lack of training facilities and career opportunities. The Australian Government expressed a strong preference for NASA Carnarvon to be manned and operated by the Australians and Australian industry. The majority of NASA Carnarvon's staff were Australians and training was mainly undertaken onsite. The opening of the tracking station led to growth in town infrastructure, increased educational opportunities and cultural activities.

NASA Carnarvon actively participated in numerous space missions and projects:

- Gemini – Rehearsal during ten missions of critical manoeuvres needed for the Apollo program missions.
- Apollo – Tracking the 16 missions which culminated in sending and landing men on the moon, spacewalks and return to earth.
- Research projects – Tracking orbiting balloons, wind measurements, water vapour in deep space, lunar science experiments, solar particle alert network and atmospheric measurements.
- Skylab missions to test humans capacity to work in space for long periods.
- Satellites – Meteorological, earth resources technology, Skynet.

To provide NASA Carnarvon with communications support, NASA contracted OTC (Overseas Telecommunications Corporation, Australia) to build the first ever satellite-earth station in Australia. It opened in 1966. From 1969 it also had satellite tracking functions separate from NASA, and provided the first ever live TV broadcast from Australia to the outside world. In its last operation in 1985-86 it tracked for the European Space Agency the passage into deep space of the Giotto spacecraft. This nomination details the contribution of OTC Carnarvon in supporting NASA's Carnarvon Operations.

The story of NASA and OTC in Carnarvon is one of technological and engineering achievement of the highest order – participation in NASA's programs including landing men on the moon and return them safely. It is also a story of the social impact on a small rural town of the influx of an urban high-tech workforce who contributed to and blended in well with the community.

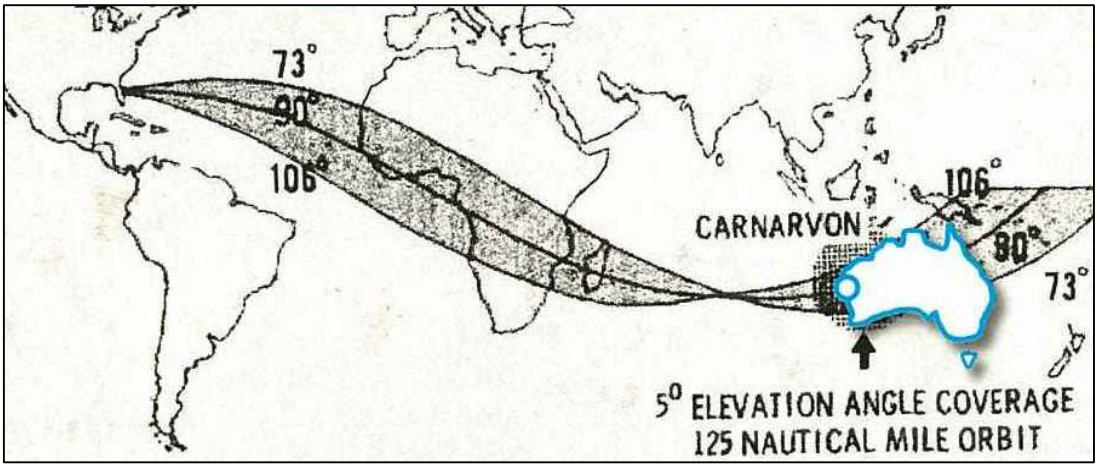

Figure 1.1. This map shows the trajectory after launch passing over Carnarvon

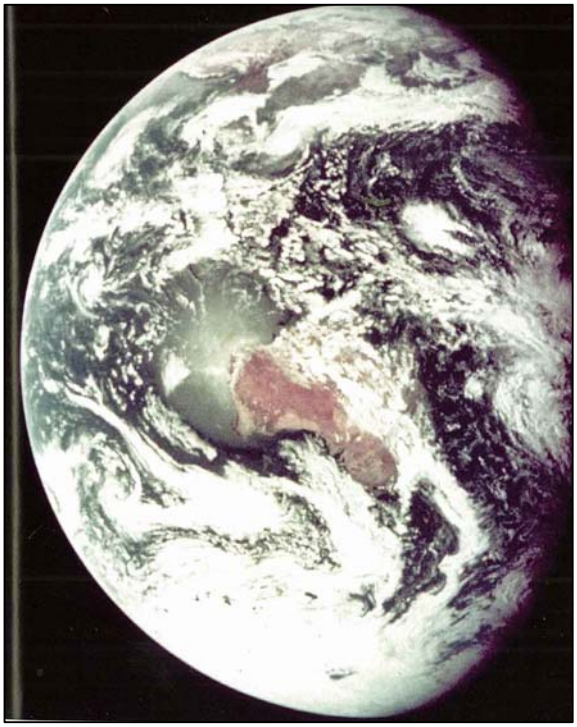

Figure 1.2. Photo of Western Australia taken from Apollo 17 on its way to the moon

2.0 STATEMENT OF SIGNIFICANCE

NASA and OTC Carnarvon have significance in the history of Australia, and in particular they:

- Have scientific value as they demonstrated a high degree of technical innovation and achievement.
- Have social value as they contributed to the cultural and physical development of the Town of Carnarvon.
- Contributed to the exploration of space, participation in which has been rare in Australia.

NASA Carnarvon provided critical support for the Manned Spaceflight Network (MSFN) missions of Gemini and Apollo which led to men walking on the moon in missions between July 1969 and December 1972, followed by the Skylab missions.

NASA Carnarvon's Satellite and Tracking Data Acquisition Network (STADAN) supported numerous satellites in a scientific analysis of the near space environment and the Earth's weather patterns, its land and marine resources and reflecting laser beams from the Moon.

NASA Carnarvon's FPQ-6 radar, the most accurate radar of its time, tracked manned-space flights, deep space missions, and scientific, defence and communication satellites and in addition participated in research projects involving rockets, water vapour clouds in space, wedge-tailed eagles, and orbiting balloons.

NASA Carnarvon's Solar Particle Alert Network (SPAN) observatory monitored solar flares and recorded 'signals' from the planet Jupiter.

OTC Carnarvon was associated with various NASA space projects, including the Apollo project which successfully landed the first men on the moon in July 1969. It illustrates the principal characteristics of the earth stations constructed as a result of the global communications system and holds a significant social value to the Carnarvon community.

The OTC Carnarvon was the first earth station built in Australia by the OTC and was one of only eight satellite earth stations in the world which carried out the function called Tracking, Telemetry, Command and Monitoring (TTC&M).

Figure 2.1. The Lunar module on return to the command service module near the moon

3.0 LOCATION

The geographical locations of NASA and OTC Carnarvon are illustrated in Figure Layout of NASA Carnarvon tracking station is shown in figure 8.1.

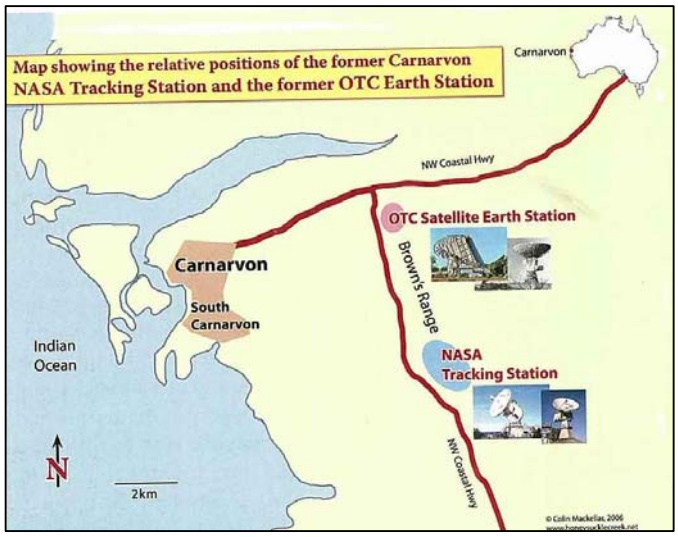

Figure 3.1. Map of Carnarvon showing the relative location of the OTC and NASA stations

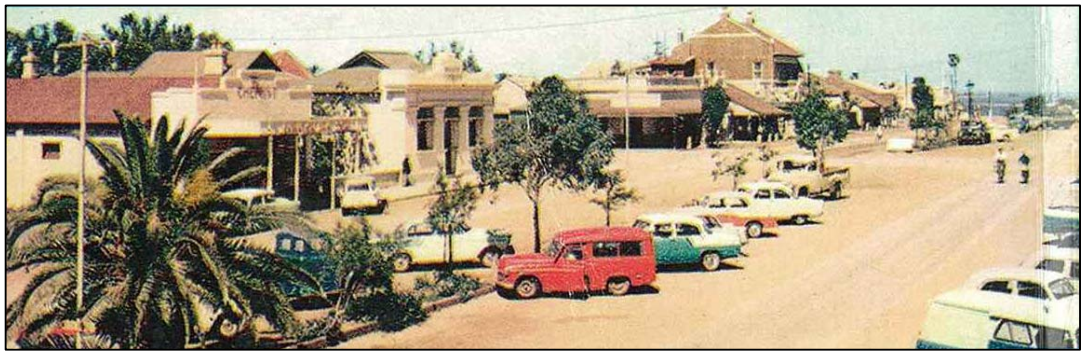

Figure 3.2. Carnarvon circa 1964

4.0 HERITAGE RECOGNITION NOMINATION FORM

The Administrator
Engineering Heritage Australia
Engineers Australia
Engineering House
11 National Circuit
BARTON ACT 2600

Name of Work: NASA Space Tracking Station Carnarvon

The above-mentioned work is nominated for an award under the terms of Engineering Heritage Australia's Heritage Recognition Programme.

Location, including address and map grid reference:

Ex NASA site
Brown Range
North West Coastal Highway
12km South East of Carnarvon CBD
24°54'S, 113°43'E

OTC site
Craggs Court and Mahoney Avenue
6km East of Carnarvon CBD
24°57'S, 113°44'E

Owners (names & addresses)

Ex NASA site – Broadcast Australia Pty Ltd
Ex OTC site – Shire of Carnarvon and private owners

The owners have been advised of this nomination and therein letters of agreement are attached.

Access to sites:

Ex NASA site – From North West Coastal Highway. Owners agreement required access to the site.

Ex OTC site – From North West Coastal Highway. Site open to the public.

Nominating Body: Engineering Heritage Western Australia, Engineers Australia, Western Australia Division.

.....
Professor Mark Bush, Chair of EHWA

Date:

5.0 OWNER'S LETTER OF AGREEMENT – NASA CARNARVON

5.0 OWNER'S LETTER OF AGREEMENT – OTC CARNARVON

6.0 HISTORICAL SUMMARY

6.1 Space Exploration and NASA Carnarvon's Role

In the 1950's the USA constructed eleven Minitrack stations around the world to support its Vanguard and Explorer space rocket program including one at Woomera which was built in 1957.

On 4 October 1957, just as the Minitrack network became operational, the USSR launched Sputnik-1 into orbit around the Earth. The USA modified five of its Minitrack stations including Woomera, so that the station could track Sputnik-1 and the later Sputnik-2. In January 1959 the USSR became the first nation to reach the Moon with an unmanned vehicle, followed by the USA with Pioneer-4 a few weeks later.

On 26 February 1960, the United States and Australia, in a 'formal exchange of notes' established a partnership to build several specialised space tracking stations in Australia, to support the Manned Space Flight Network (MSFN), the Deep Space Network (DSN) and the Satellite Tracking and Data Acquisition Network (STADAN) programs.

Australia contributed US$140,000 per annum to NASA's billion-dollar budget in exchange for autonomous operation of NASA stations in Australia; the only nation with that privilege. Australia provided the land, the staff and built the facilities and the US provided training, technical equipment and equipment installation support. Electric power was generated onsite to US standards.

Two MSFN tracking stations were subsequently opened to support the Mercury program, a command station at Muchea, near Perth and a support station at Red Lake, Woomera. Later in 1960, a DSN station opened at Island Lagoon, Woomera, with a relocated Minitrack facility.

The world was shocked when Cosmonaut Yuri Gagarin became the first astronaut to orbit the Earth on 12 April 1961. A few weeks later on 5 May 1961, the USA followed with the first of two suborbital astronaut flights. Then on 20 February 1962, Astronaut John Glen completed three orbits over the Muchea command station. In the interim, President Kennedy had declared that before 1970 the USA would be "landing a man on the Moon and returning him safely to Earth." Eight months later, the USSR made a similar commitment. Three more manned missions were to cross Muchea station before it closed in 1963. However, the Gemini and Apollo phases of the USA's MSFN Moon program required the establishment of a MSFN command station at a more northerly location in Western Australia. The Carnarvon Tracking Station, built in 1963 to meet those requirements, became the largest tracking facility outside mainland USA. It was essentially four stations at one location and included;

- An MSFN tracking station to support astronauts orbiting the Earth and travelling to the Moon and back, prime for Trans-Lunar Insertion and re-entry to the Earth's atmosphere;

- A Goddard Range and Range Rate tracking station to support scientific and applications satellites (NASA's first STADAN station in Australia);

- An FPQ-6 precision long-range radar to support the MSFN and STADAN facilities and the launch and early planetary insertion of phases of DSN spacecraft;

- And, in 1965, a Solar Particle Alert Network (SPAN) station to monitor solar and terrestrial events possibly hazardous to astronauts in space.

With expanding NASA operations, four more stations were completed in Australia: a second DSN station, Tidbinbilla, ACT, in March 1965; a second STADAN station, Orroral Valley, ACT, in October 1965; a second MSFN station, Honeysuckle Creek, ACT, in March 1967 (Red Lake station having been phased out); and Cooby Creek, a transportable Applications Technology Satellite Ground Station opened in October 1966, near Toowoomba, QLD.

Australia became the fourth nation to launch a satellite on 29 October 1967, placing WRESAT into a highly elliptical retrograde orbit northwesterly across Carnarvon from its Woomera launch. Carnarvon's long range radar confirmed that WRESAT had achieved orbit while its STADAN facility collected 43.5 minutes of data in the first orbit.

In late 1971, a truncation of the manned space program, a reduction in NASA funding, and economies offered by technological advances forced a merger of the MSFN and STADAN network to a smaller Spaceflight Tracking and Data Network (STDN), a worldwide reduction from 23 to 15 stations over several years – the DSN network remained a separate entity. Despite a reduction in the number of manned space flights, Carnarvon's operational load peaked with extensive support of Skylab missions, of Apollo Lunar Surface Experiment packages still transmitting from the Moon's surface and also support of the Earths Resources Technology Satellite (ERTS).

A number of station closures now followed: Island Lagoon closing in December 1972; Honeysuckle Creek in February 1974, though continuing as a Tidbinbilla wing until 1981; and Carnarvon ceasing operations in December 1974 with transfer of its operations to an enhanced Orroral Valley station. All Australian support was now centralised to the ACT.

NASA earth-orbit tracking stations finally became redundant with the development of the Tracking Data Relay Satellite System, a network of synchronous satellites providing the same service from 1983 onwards, Orroral Valley closing in late 1984.

All that now remains of NASA's space-tracking stations is the DSN network; stations at Tidbinbilla, ACT now known as the Canberra Deep Space Communications Complex and at Madrid, Spain and Goldstone, California.

NASA's Carnarvon Tracking Station closed in December 1974 for ultimate replacement by a network of Tracking and Data Relay Satellites (TDRS) soon to be in place to support all earth orbiting spacecraft.

Figure 6.1. The T&C Road showing the completed USB antenna on the ridge at the right and a ‘trophy from Dallas’ on the roadside, bottom left

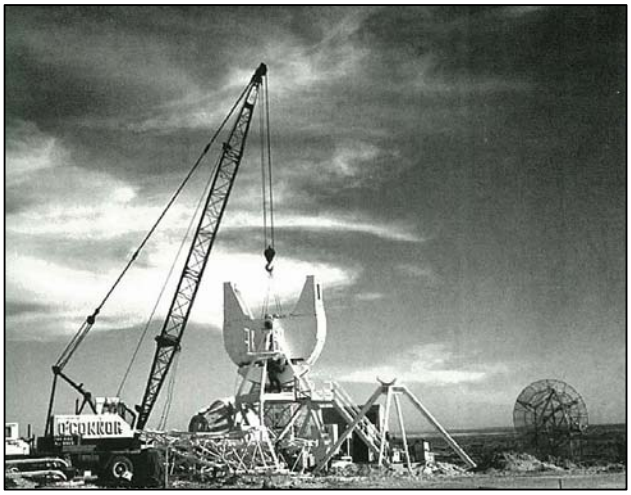

Figure 6.2. The assembly of the USB antenna

6.2 OTC Carnarvon

On 8 April 1964, Carnarvon Tracking Station had lost communication with NASA's mission control centre during the Gemini 1 mission.

To ensure reliable communications, particularly for the Apollo missions, NASA contracted the Overseas Telecommunication Commission Australia (OTC) to build Australia's first Satellite-Earth Station, 6km north of the Tracking Station. The 12.8m by 16.5m Casshorn antenna, known as the 'Sugar Scoop', was completed in early October 1966. NASA had also commissioned the Intelsat Corporation to place a geosynchronous communications satellite above the mid-Pacific Ocean to complete the link between Carnarvon and the USA.

In 1969, OTC constructed a new antenna to provide routine communications, a 29.7m parabolic dish. The Casshorn antenna was re-assigned to be one of only four Tracking, Telemetry and Control (TT & C) stations around the world and the only one in Australia and later still, in 1970, becoming a Tracking, Telemetry, Command & Monitoring (TTC&M) station with the addition of 'monitor' facilities.

Before April 1975 the OTC earth station did not track NASA spacecraft nor did it receive signals directly from the moon, but acted as a relay station for Carnarvon Tracking Centre.

OTC's TTC&M station ceased operations in November 1984 followed by the closure of all OTC satellite-earth operations from Carnarvon in December 1985; advances in space technology using higher transmission frequencies impelled a more efficient location at Gnangara, Perth, on the outskirts of a city. However, in 1980, the OTC site had become a tracking station in the full sense when it received a five year European Space Agency (ESA) contract to support the European space program. ESA had installed two VHF antennas for launch and earth orbit support and a 15m S-band dish for deep space support, notably the Giotto spacecraft on its voyage to pass through the tail of Halley's Comet on 13 March 1986.

The OTC facility finally closed on the 14 March 1986 leaving only the two OTC dishes as a memorial to Carnarvon's 23 years association with NASA, OTC and ESA space activities.

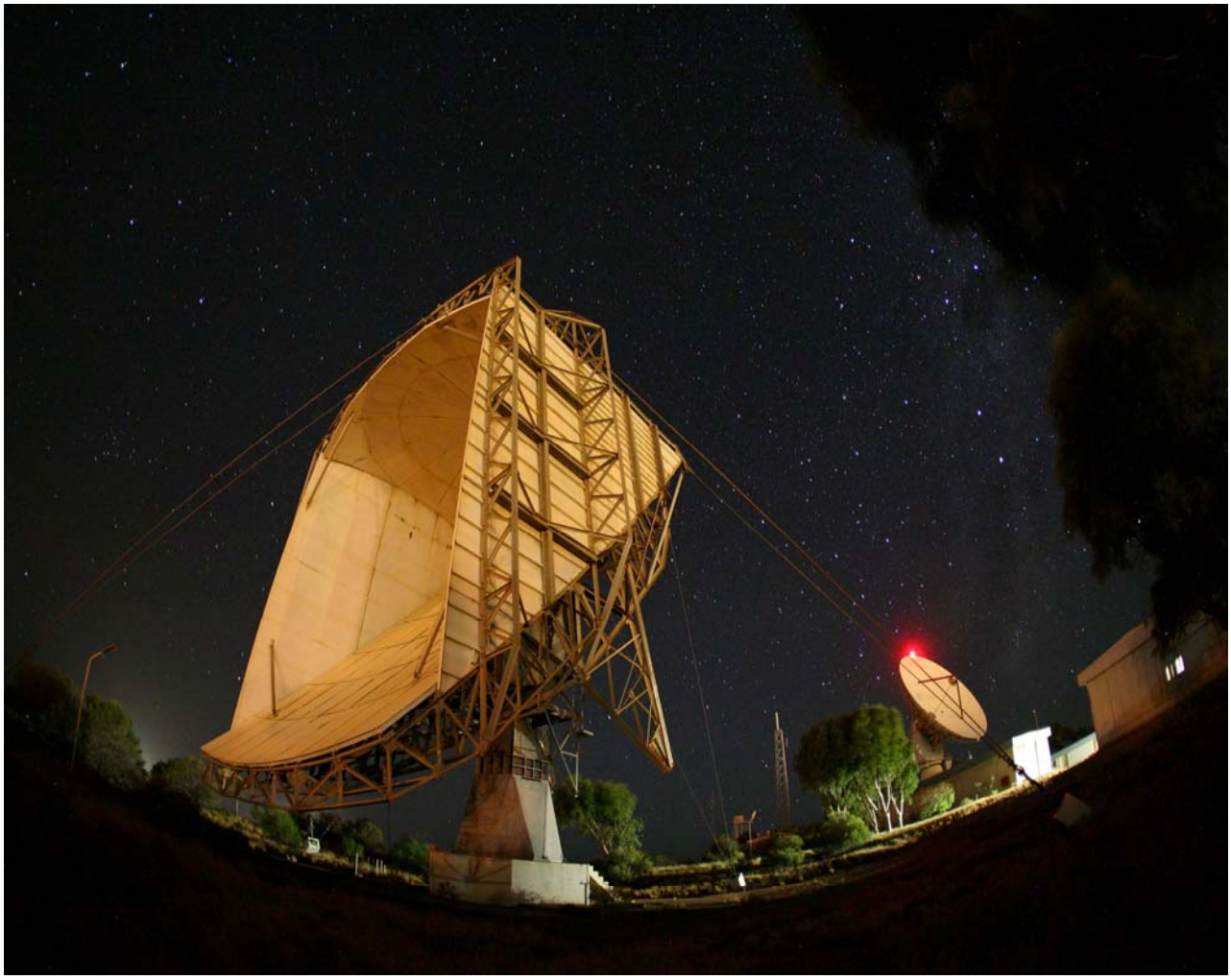

Figure 6.3. OTC Carnarvon Casshorn Antenna with the parabolic dish antenna in the background

Figure 6.4. OTC Carnarvon 29.7m Parabolic dish antenna

7.0 BASIC DATA

7.1 NASA Carnarvon Space Tracking Station

Item Name: NASA Carnarvon Space Tracking Station

Location: 24°54'S, 113°43'E

Address: Brown Range. North West Coastal Highway, 12km South East of Carnarvon CBD

Suburb/Nearest Town: Carnarvon

State: Western Australia.

Local Govt Area: Shire of Carnarvon

Owner at time of NASA Carnarvon Tracking Station: Department of Finance and Administration, Canberra.

Owner – Current: Australian Federal Government. Occupied by Broadcast Australia Pty Ltd (?)

Current Use: Broadcast Australia Pty Ltd operations.

Former Use: Pastoral

Designer: NASA

Maker/Builder: NASA and Australian Contractors

Year Started: 1963

Modifications and Dates: Numerous – 1963 to 1974. Refer to Historical Summary.

Historical Notes: refer to Historical Summary.

Heritage Listings: Heritage Council of Western Australia – No Listings.
Place No: 13853 : Name: NASA Tracking Station (FMR).
Assessment Program Adopted 30/07/1999.

7.2 Carnarvon OTC Satellite Earth Station

Item Name: Carnarvon OTC Satellite Earth Station

Location: 24°57'S, 113°44'E

Address: Near Craggs Court and Mahoney Drive. North West Coastal Highway, 6km East of Carnarvon CBD

Suburb/Nearest Town: Carnarvon.

State: Western Australia.

Local Govt Area: Shire of Carnarvon

Owner – Current: Shire of Carnarvon. (Lot 40 and Road Reserve)

Water Corporation of Western Australia (Reserve 26193)

Boddee Pty Ltd (balance of land)

Owner – at time of OTC Carnarvon Operations: Overseas Telecommunication Corporation, Australia.

Former Use: Pastoral

Designer: OTC

Maker/Builder: OTC & Australian Contractors

Year Started: 1965

Modifications and Dates: 1969 & 1980s. Refer Historical Summary, Section 6.2

Historical Notes: refer to Historical Summary, Section 6.2.

Heritage Listings: Heritage Council of Western Australia
Place No: 00472 : Name: OTC Satellite East Station (Fmr).
Permanent Entry. Registration of Heritage Places 04/05/2001
Municipal Inventory: Adopted Antenna only 24/01/1996.

8.0 PHYSICAL DESCRIPTION AND CURRENT CONDITION

8.1 NASA Carnarvon Tracking Station

The site, initially undeveloped, consisted of roads, buildings, vans, antennas, dishes and masts, spread over an area of approximately 1.8 square kilometres.

The five principal locations were the Telemetry and Command (T&C) facilities; FPQ-6 Radar; Goddard Range and Range Rate (GRARR); the Power Station and the Solar Particle Alert Network (SPAN).

To the west, the GRARR facility was located with two vans, a VHF antenna and two-dish S-Band antenna. This would provide ranging and data collection for a wide variety of scientific satellites as part of the Satellite Tracking and Data Network (STADAN).

To the northern end of the site was located the equipment building and the 8.8m parabolic dish antenna of the FPQ-6 high precision C-Band radar, Carnarvon's first dish and one of only two in the NASA network. Known as Q-6, it would support a wide range of launch and orbital activity on many different NASA and US Department of Defence projects.

To the east of the site, the T&C building housed the station administration and all the communications, telemetry, command and tracking acquisition equipment necessary to support the Manned Space Flight Network (MSFN). It included a control room where the Operations Supervisor coordinated the mission activities of the station. Around this building were several vans and related antennas; the ex-Muchea VERLORT S-Band radar with its dish mounted on a concrete tower alongside its van (a backup for the Q-6 radar); two Acquisition Aid (AcqAid) antennas to independently track the Gemini spacecraft and the Agena Target Vehicle and two steerable HF antennas for backup communication with potentially stranded astronauts. Located to the west of the T&C building between GRARR and the Power Station were three vans and two antennas for spacecraft communications and command facilities.

The SPAN observatory, one of only three in the NASA network, located just west of the station entrance road monitored sunspot activity. An ancillary antenna provided early warning of radiation danger to astronauts in space. The SPAN facility also included a two-antenna Yagi interferometer to monitor radio transmissions from the planet Jupiter.

The Power Station located in a low-lying area central to all the other facilities reticulated a 110 V a/c supply around the site via cyclone-proof underground cables. Powerhouse facilities included workshops and technical stores to support all other CRO sections.

A range of other facilities were located around the site. On each of two minor dunes stood collimation masts for calibration of the GRARR and Q-6 systems and near the T&C building stood a time synchronisation broadcasts antenna array to check that the station clock was synchronised to the world network, thus ensuring that its tracking data would be precisely and accurately timed.

All that now remains of the station are a few concrete footings.

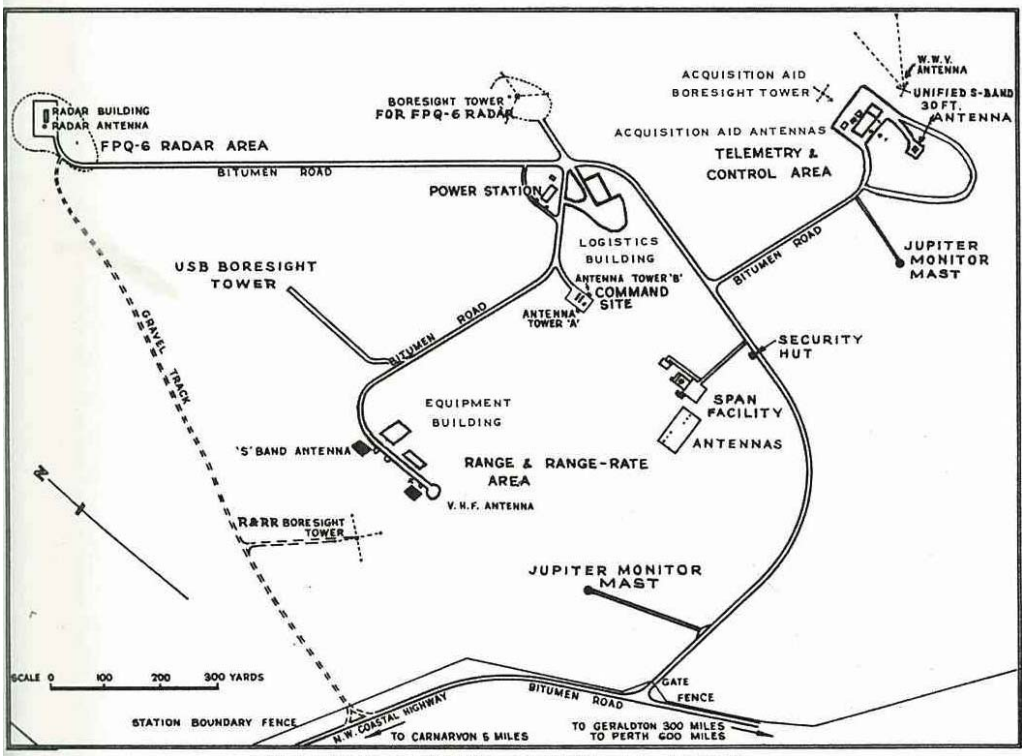

Figure 8.1. Carnarvon Tracking Station site layout

Figure 8.2. The Carnarvon Space Tracking Station, 1969. At the top, towards the south, is the T&C building with the USB dish. Bottom left is the FPQ-6 radar with the GRARR facility aside to the right. Across the centre, from left to right, are the Power Station, the UHF Command antennas and the SPAN facilities. The station entrance is bottom right, with Tickle Belly Flats upper left.

8.2 Carnarvon OTC Satellite Earth Station

The site comprised single men's quarters, recreation building and facilities, administration control building, workshop, observatory, powerhouse and fuel shed, telecommand equipment shelter, antennae and reflector.

OTC Carnarvon closed in 1987 when the Gnangara OTC Earth Satellite station opened.

The 12.8m by 16.5m Casshorn antenna, known as the 'sugar scoop' and the 29.7m parabolic antenna, referred to as the 'dish' remain. These are no longer operating and are in fair physical condition.

The place is now a tourist precinct.

The staff quarters (25 houses) associated with the place are now all in individual, private ownership. They are not included in the Tourist Precinct.

Figure 8.3. The OTC station. The 'sugar scoop' dish on the left supported the Apollo 11 TV relay to Perth; the big dish had not then been commissioned

9.0 ASSESSMENT OF SIGNIFICANCE

9.1 Creative and Technical Achievement

- NASA's Carnarvon Tracking Station became the largest space-tracking complex in the world outside mainland USA. Effectively four stations in one, it supported the Manned Space Flight Network (MSFN), the Spaceflight Tracking and Data Acquisition Network (STADAN), the Solar Particle Alert Network (SPAN) and included a long-range precision tracking radar, supporting MSFN and STADAN missions and also the early orbit support and insertion into outer space of Deep Space Network (DSN) missions. At its peak, the station employed 220 engineers, technicians and support staff.

- Diametrically opposed (antipodal) to the Cape Canaveral launch site, the tracking station was the first able to track and confirm the status of a newly launched manned spacecraft on its first orbit and then for the next several orbits, with its data acquisition vital to the continuation of each mission.

- NASA Carnarvon was the first Gemini tracking station upgraded to support Apollo missions. The higher launch angle was again necessary to place the Apollo spacecraft into the ideal position for a Trans-Lunar Insertion (TLI) manoeuvre taking it to the Moon. On the way to the Moon and back again, the station provided triangulation tracking support and then was the critical station for the Apollo re-entries into the Earth's atmosphere for a planned Pacific Ocean splashdown.

- A GRARR (Goddard Range and Range Rate) tracking station, part of STADAN network, was constructed at Carnarvon for tracking, data acquisition and command of scientific satellites in cis-lunar space.

- NASA Carnarvon and OTC had important roles to play in rectifying a jammed solar array on Skylab Laboratory launched in May 1973. NASA arranged for two ABC microwave vans to be rushed up from Perth for the live relay of television images received by Carnarvon onto OTC then directly onto Mission Control for NASA engineers to begin developing procedures to release the jammed wing. Many days later, Astronauts implemented the control centre's solution to the jammed solar array and the Skylab rescue was partially complete.

- Australia became the fourth nation to launch a satellite, placing WRESAT (Weapons Research Establishment Satellite) into a highly elliptical retrograde orbit on 29 November 1967. NASA Carnarvon's FPQ-6 radar confirmed that WRESAT had achieved a good orbit while its STADAN facility collected 43.5 minutes of telemetry data on the first orbit. Data collection continued until the satellites batteries expired 73 orbits later.

- OTC's Casshorn antenna relayed the first live TV of Neil Armstrong's first steps on the Moon from NASA's Honeysuckle Creek Station, up to 'Intelsat III F-4' above the Pacific Ocean, down to OTC Carnarvon and along the coaxial cable to Perth TV audiences.

- NASA and OTC Carnarvon are of great significance as they contributed to technological and engineering achievements of the highest order, participating in NASA's programs including landing men on the moon and returning them safely to earth.

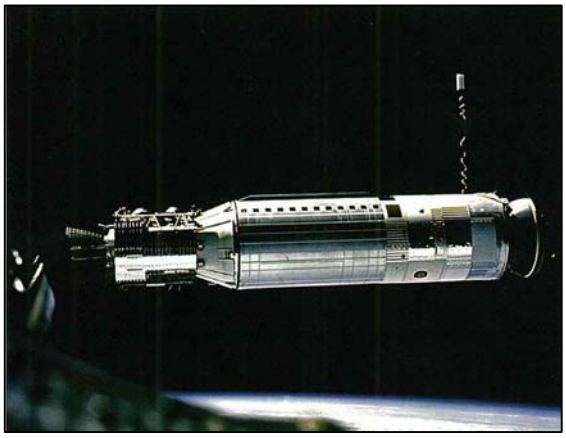

Figure 9.1.Agena 8 photographed from a rendezvousing Gemini 10

Figure 9.2. Skylab 3 departure photo shows the neater more-effective sunshade in place, with the old sunshade peeping out at the edges

Figure 9.3. Gemini Control Room with Dick Simons at the M&O Console, front, and John Fletcher and Dave Brookes to the rear.

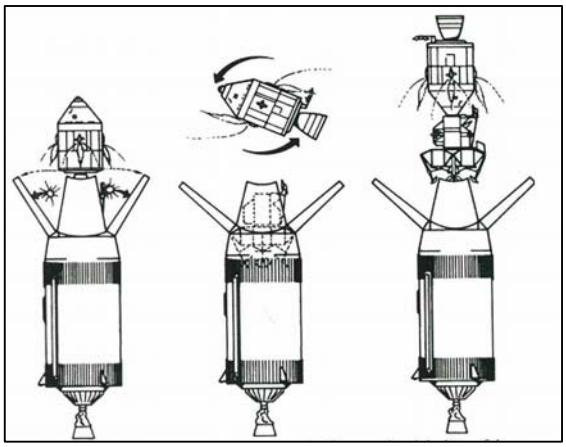

Figure 9.4. Transposition diagram illustrating the fly-around and docking of the Lunar Excursion Module

9.2 Social Significance

The opening of the Carnarvon NASA tracking station in 1964 markedly changed a quiet, mainly fishing and pastoral town, with a population of 2,000, as highly qualified engineers and technicians arrived.

At its peak NASA Carnarvon employed 220 engineers, technicians and support staff. With their families, the population of Carnarvon increased markedly.

Growth in the town population led to the expansion of housing, schools, a wide variety of services, cultural and sporting activities and increased technical education opportunities. The trackers and their families led the way in establishing many of these activities.

The 1971 Australian Census showed that a higher proportion of Carnarvon citizens had a tertiary qualification than Canberra.

The employees of the tracking station and their families made an outstanding social contribution to Carnarvon which has been of lasting benefit to all members of the community.

Figure 9.5. Captain Bill and teacher Elli with the Kindergarten class below the DC-6B aircraft at the Carnarvon airport

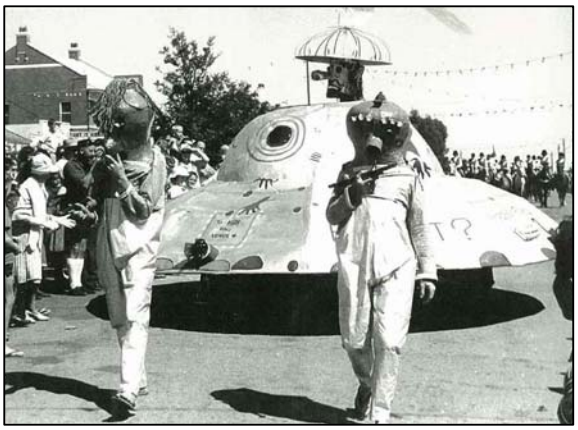

Figure 9.6. Flying Saucer from Venus terrified spectators at the Carnarvon Festival early September 1967

9.3 Rarity

- NASA Carnarvon was one of only two NASA stations with an FPQ-6 long-range precision tracking radar, the most accurate in the world; the only station that could support both early orbit definition and the early post insertion phase of MSFN and DSN missions from Earth to outer space, the Moon and the planets.

- NASA Carnarvon was the only station in contact with the crippled Apollo-13 in April 1970 for three hours immediately prior to re-entry during which the station transmitted procedures for the power-up of the Command Module.

- Australia contributed funds to NASA's billion-dollar budget in exchange for autonomous operation of NASA stations in Australia; the only nation with that privilege.

- The OTC Satellite-Earth Station Carnarvon was the first such station built in Australia and at the time one of only six around the world.

- OTC Carnarvon carried the first live TV broadcast to a public audience in Western Australia – Apollo 11 astronauts walking on the Moon's surface.

- OTC Carnarvon provided TCC&M management of geosynchronous communications satellites over the Indian and Pacific Oceans; one of four such stations around the world.

- OTC Carnarvon became one of the three deep-space ESA stations around the world, established to monitor the passage of Giotto spacecraft through the tail of Halley's Comet and to examine its cometary dust.

- The OTC Casshorn antenna is believed to be the only one of its design remaining in the world.

9.4 Representativeness

The two OTC antennas still standing at the OTC satellite-Earth Station at Carnarvon represent the cutting edge of space communication technology when they were first brought into service and are excellent examples of the space tracking technologies of the 1960s.

9.5 Integrity

The integrity of NASA Carnarvon is low. All that remains are a few footings.

The integrity of OTC Carnarvon is high. The two antennae, both significant and large structures dominating the landscape, remain.

Figure 9.7. All that remains of NASA Carnarvon's Apollo tracking antenna are its concrete foundations

10.0 HISTORIC INDIVIDUALS ASSOCIATED WITH NASA AND OTC CARNARVON

US President John F Kennedy

Neil Armstrong
Astronaut and first man to step foot on the moon.

Buzz Aldrin
Astronaut and Lunar module pilot on Apollo 11, the first manned landing on the moon.

Charles 'Pete' Conrad
Astronaut and third person to set foot on the moon.

Wilson Tuckey
Town of Carnarvon Mayor (1964). Shire of Carnarvon President (1965-1971).

Allen Fairhall
Australian Minister of Supply (1961-1965).

Paul Dench
Telemetry Engineer. AWA Company Manager Carnarvon.

US President John F. Kennedy

President Kennedy, the 35th President of the United States, made the historic challenge to the American nation over fifty years ago on 25 May 1961 at a joint session of Congress: to put a man on the moon and return him safely to Earth before the end of the 1960s. Few people outside the aero-space industry realised the huge undertaking that this would involve and no one could have predicted that a small outback town in Western Australia would provide a 'key stepping stone' to the Moon.

President Kennedy was born on 29 May 1917 in Massachusetts into a wealthy Irish-American family and was educated at Harvard University, graduating in 1940. After war service in the US Navy in the Pacific, he entered politics in 1946 when he was elected as a Democrat to the House of Representatives and, in 1952, he was elected to the Senate. He won the Democratic presidential nomination in 1960 and beat Richard Nixon in the subsequent election to become the country's youngest president.

Kennedy's presidency was marked by Cold War tension both in space and foreign affairs. The unexpected launch of Sputnik 1 in October 1957 had given the Soviets an early advantage. When Russian cosmonaut, Yuri Gagarin, became the first man to enter space and orbit the Earth, on 12 April 1961, American pride was dealt a body blow. Five days later came news of the disastrous failure of the Bay of Pigs American backed invasion of Cuba. Although the gloom was somewhat relieved by a sub-orbital flight by Alan Shepard in Mercury 3 on 5 May, when Kennedy gave his speech on 29 May he felt that the USA had to answer the Soviets by demonstrating its technological superiority and international leadership. But the challenge to put a man on the moon was not just a visionary goal. After Gagarin's flight Kennedy had sought advice on how to beat the Soviets in space and had been advised that because the USA had a lead in the type of large rockets needed for a manned moon landing, that should be the goal.

NASA planned a three stage strategy to put a man on the moon. First would be the one-man Mercury spacecraft, then the two-man Gemini craft and finally the three-man Apollo missions. The decision to implement the strategy transformed NASA into a huge infrastructure with an important public profile and a total Apollo budget of $25 billion (which would be four times that today). But without the inspiration of Kennedy's speech and the 'convergence of the politics of the time with the dreams of centuries' the human footsteps in the moon dust might never have been made. Tragically Kennedy was assassinated on 22 November 1963 before any of the Gemini and Apollo missions had been launched.

Neil Armstrong

Professor Neil Alden Armstrong is the former American astronaut who was the first person to set foot on the Moon when he spoke the famous words. 'That's one small step for man, one giant leap for mankind.' Neil Armstrong was born in Ohio on 5 August 1930 and studied aeronautical engineering at Purdue University. After two years at Purdue he spent three years of service in the United States Navy including 78 missions in the Korean War. He completed his Purdue BSc degree in 1955 and was awarded an MSc degree in aerospace engineering by the University of Southern California in 1970. From 1955 he served as an experimental research test pilot at Edwards Air Force Base where he flew over 900 flights in a variety of aircraft. In 1958 he was selected for the US Air Force's military space plane project and in September 1962 he joined the NASA Astronaut Corps.

Armstrong's first spaceflight, in March 1966, was the NASA *Gemini 8* mission with fellow astronaut David Scott. The mission was to be NASA's most complex yet, involving a rendezvous and docking with an unmanned *Agena 8* target vehicle. The launches and docking were completed successfully but shortly after docking the linked vehicles lurched into high speed uncontrollable tumbling and spinning. Separation of the vehicles failed to stop the spinning so Mission Control ordered an emergency splash down in the North Pacific. Armstrong had another assignment on the Gemini program when he was backup command pilot for *Gemini 11*. The vehicle's crew successfully completed their tasks while Armstrong acted as capsule communicator. After the *Gemini 11* flight President Johnson asked Armstrong and his wife and two other astronauts and their wives to take part in a goodwill tour of South America which took in 11 countries and 14 major cities.

In the Apollo program Armstrong served as backup commander for *Apollo 8* which was the first manned spacecraft to orbit the moon. He was then chosen as commander for *Apollo 11* which was planned to land on the moon, with Buzz Aldrin as lunar module pilot, and Michael Collins, as command module pilot. After a successful launch, during the second orbit the Carnarvon Tracking Station transmitted the 'GO for TLI' command to trigger the trans-lunar injection burn which sent the three astronauts on their way to the moon. Three days later Armstrong piloted the lunar module, *Eagle*, down to the Moon's surface. Failing to see a smooth landing site, he switched from automatic to manual mode as he approached the surface. Tension rose at Mission Control as the small quantity of fuel remaining for the landing had nearly been exhausted. Eventually came the message. 'Houston, Tranquillity Base here. The *Eagle* has landed!' Armstrong and Aldrin then prepared for their moonwalks. Armstrong stepped onto the moon's surface at 2.56 (Universal Time) on 21 July 1969, speaking his famous words ' That's one small step for man, one giant leap for mankind.' Aldrin joined Armstrong and the two spent about two and a half hours on scientific and commemorative activities. They rejoined the Lunar Module which was launched successfully and made its rendezvous and docking with the command module. The three astronauts returned to Earth and splashed down in the Pacific. Four months later they undertook a 22 nation world tour which included a visit to Australia during which they attended a public reception in Perth where Armstrong thanked the people of the Carnarvon Tracking Station for their contribution to the Moon landings.

In 1971 Armstrong resigned from NASA to become Professor of Aerospace Engineering at the University of Cincinnati where he taught until retirement in 1979. He has been a member of two spaceflight accident investigations and has served on the boards of directors of a number of American companies.

Buzz Aldrin[1]

Dr Edwin Eugene 'Buzz' Aldrin is the former astronaut who was the lunar module pilot on *Apollo 11*, the first manned landing on the moon, and on 26 July 1969 was the second man to walk on the moon. Aldrin was born on 20 January 1930 in Mountclair, New Jersey, and graduated in mechanical engineering from the United States Military Academy at West Point in 1951. He became an Air Force officer and served as a fighter pilot during the Korean War flying 66 combat missions. In 1963 he was awarded a doctorate in Orbital Mechanics at the Massachusetts Institute of Technology and was selected as a member of NASA's third group of astronauts for intensive training for the Gemini and Apollo programs. His first space mission was *Gemini 12* with fellow crewman, Jim Lovell, which was launched in November 1966. Prior to the mission Aldrin pioneered the use of underwater training to simulate spacewalking. During the flight he carried out a spacewalk which lasted a record 5½ hours which proved that astronauts could work outside orbiting vehicles to make any necessary repairs. In December 1968 Aldrin was back-up command module pilot for *Apollo 8*, the first manned spacecraft to orbit the moon. In 1969 he was chosen to be one of the crew for Apollo 11 the lunar landing flight (July 16-24 1969). Aldrin joined Armstrong on the Moon's surface 19 minutes after Armstrong had made the first step. They completed their schedule of surface activities which included laying out the scientific instrument package (Early Apollo Scientific Experiments Package – EASEP) for which Carnarvon Tracking Station sent the command signal to activate and then received its first transmitted data. The two astronauts returned to lunar orbit to rejoin Collins for the return to Earth. They later embarked on a good will tour for NASA. They were extensively feted and received honours from around the globe and spoke and wrote about their unique experiences.

Aldrin resigned from NASA in 1971 and then served as Commandant of the Test Pilot School at Edwards Air Force Base until retiring from the Air Force in 1972. Subsequently he continued to be a strong advocate of space exploration and founded a private rocket design company.

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[1] Aldrin made Buzz his legal first name in 1988.

Charles 'Pete' Conrad

'Pete' Conrad was the astronaut who commanded Apollo 12 on the second manned landing on the moon, and was the third person to walk on the Moon. He was also one of the astronauts who came to Carnarvon in 1965 with some of the teams of flight controllers which NASA sent to Carnarvon Tracking Station for each of the Gemini space flights.[2] These astronauts who came to Carnarvon the station trackers proudly called the 'Carnarvon astronauts'.

Conrad was born on 2 June 1930 in Philadelphia, Pennsylvania, and graduated in aeronautical engineering at Princeton University in 1953. He learnt to fly while still at high school and joined the United States Navy on leaving Princeton, becoming a carrier pilot and later a naval test pilot. He joined NASA in its second intake in September 1962.

By March 1965 Carnarvon was ready to support its first manned mission, Gemini 3. Conrad came to Carnarvon as the astronaut with the four flight controllers. He impressed the local sports clubs with his outstanding fitness and the trackers with his sense of humour. The mission was successful despite some conflicting instructions from the chief flight controller and the astronaut. Conrad's first mission in space was in August 1965, as pilot in Gemini 5 with commander Gordon Cooper. It was an Apollo-length mission of 128 earth orbits which set a new space endurance record of 7 days 23 hours. He was then back-up commander in March 1966 for Gemini 8 which unsuccessfully attempted to dock for the first time with another space craft.

In September 1966 the Gemini 11 mission, with Conrad as commander and Richard Gordon as crewman, required a critical manoeuvre early in the flight : a rendezvous and docking with Agena 11 during the first orbit, just as the lunar module would be required to do with the command module after leaving the surface of the moon. The manoeuvre was completed successfully with five minutes to spare. The combined vehicles then orbited to a record high earth orbit of 1368.9km.

Four months after the first manned landing on the moon, Apollo12 with Conrad, Gordon and Alan Bean prepared to take off for the second flight to the moon. On the last day of the 3 day launch window, the launch was delayed by storm activity and then lightning struck the spacecraft twice within a minute after launch, temporarily knocking out power and guidance in the command module. However, after the trans-lunar injection to propel the spacecraft out of orbit, the mission went to plan. Both Conrad and Bean completed two walks on the Moon and the return to earth went to plan.

The last Apollo mission was in December 1972 but Conrad was required for one final mission. NASA's Skylab 1 which was to be an orbiting space laboratory was launched in May 1973 but was damaged during the launch. Its micrometeoroid shield-sunshade had been torn away taking with it one of its two main solar panels and jamming the second. Only 11 days after the launch of the laboratory, Skylab 2 with Conrad, Kerwin and Weitz aboard, lifted off to investigate the damage. Conrad and Weitz after a three hour effort managed to deploy the second solar panel and the astronauts erected a 'parasol' sunshade to protect the laboratory. After 28 days which was the longest spaceflight ever, the astronauts returned to earth, having made Skylab usable for later crews.

Conrad retired from NASA and the Navy in 1973.He then worked for American Television and Communications Company (1973-76) and for McDonnell-Douglas Corp. (1976-c.1992). In the 1990s he was involved in the testing of the Delta Clipper experimental single stage to orbit launch vehicle. He died on 8 July 1999 in California following a motorcycle accident.

[2] Support from Carnarvon for the Apollo missions was implemented by Carnarvon-based staff without it being necessary to fly in flight controllers from the USA.

Wilson Tuckey

Wilson Tuckey was the elected head of the Carnarvon local government during most of the twelve years from 1962 to 1974. in which the Carnarvon Tracking Station was being developed and operated He was Mayor of the Town of Carnarvon in 1964-65 and after the Town was amalgamated with the Shire, in 1965, he was its President until 1971 and continued as a shire councillor until 1979. Tuckey was born in Perth in 1935 and had been a businessman and hotelier in the Gascoyne Region for a number of years before the tracking station was proposed. Initially, in 1962, difficulties in providing sufficient housing for married staff employed on the NASA project nearly stalled plans for the development of the station despite lengthy negotiations between the Town Council and the Australian Government. Tuckey's predecessor as Mayor, Cec Radley, solved the impasse by proposing that the Council build the houses under a seldom-used clause in the Local Government Act. No provision, however, had been made for the housing of unmarried trackers until Tuckey, the publican of the Port Hotel, offered to build 20 motel style units at the hotel and to provide full board for their occupants. He travelled to Sydney to confirm the intentions of AWA, the company which had won the contract for maintaining and operating the tracking station.

As President of the Shire Tuckey chaired in a very active manner many of the committees which trackers and townspeople formed to lobby the state and federal governments for the better provision of schools, hospitals, airport facilities and other necessary services for the town. When the station was at its busiest operationally it employed over 200 persons few of whom were originally local residents. That number of newcomers plus their families and a string of visiting equipment installers and instructors and other NASA experts put a great strain on the infrastructure of the existing community of only 2000 people. When Carnarvon received unexpected fame through the tracking station's part in the NASA programs Tuckey became the willing interpreter to the outside world of the isolated town and its 'outback' hinterland. He also introduced to the trackers some of the unexpected leisure pursuits of the Gascoyne even to the extent of persuading his motel boarders to invest in a racehorse in order to actively participate in the local race meetings.

In 1979 Tuckey entered federal politics by winning for the Liberal Party the House of Representatives seat of O'Connor which covered a large section of rural Western Australia. He held the seat until defeated at the 2010 election. He was then aged 75 and was the oldest member of the Australian Parliament. He twice held ministries in the Howard Government, in 1998-2001 and in 2002-03. He was a controversial figure in the House but was influential in several Liberal Party leadership changes.

Allen Fairhall

Sir Allen Fairhall, K.B.E., was the Minister of Supply in the Menzies Liberal Government which was responsible for the establishment of the NASA Space Tracking Station at Carnarvon and for its operation and maintenance by the Australian company Amalgamated Wireless Australia (AWA). Fairhall was born in Morpeth, New South Wales, on 24 November 1909 and was educated at East Maitland Boys High School and Newcastle Technical College. He served an apprenticeship in electrical fitting and in 1931 founded the commercial broadcasting station 2KO Newcastle. In 1942 he became President of the Australian Federation of Commercial Broadcasting Stations. In 1941 he was co-opted by the Ministry of Munitions to become supervising engineer of the Radio and Signals Supply Section (NSW) and in that capacity during the war he had oversight of the production of wireless, signals and radar equipment for the Armed Services. He sold his interests in commercial radio in 1947.

In 1949 Fairhall entered Federal Parliament as Member for the House of Representatives seat of Patterson (NSW), an electorate covering the Hunter Valley region. He held the seat for the Liberals until he retired in 1969. He was Minister for Supply for four years from December 1961. When NASA enquired about the establishment of a major tracking station in Australia to support its Manned Space Flight and Scientific Satellite Program Fairhall, as Minister for Supply, expressed the Australian Government's strong preference for the station to be manned and operated by Australians and by Australian industry. These preferences were met by NASA although Australia was the only country in which conditions requiring the operation of a station by the country's nationals were applied. The Ministry of Supply was responsible for Australia's participation in the tracking station operations and called tenders for the maintenance and operation of the station, the contract being awarded to AWA. The Carnarvon Tracking Station was officially opened by Fairhall and NASA's Director of Tracking, Ed Buckley, on 25 June 1964.

Fairhall was subsequently Minister of Defence in the Holt and Gorton Governments. He retired from politics in August 1969 and received a knighthood in 1970. He died in 2006 aged 96.

Paul Dench

Paul Dench, telemetry engineer, was the first space craft tracker to be employed, in May 1963, by AWA (Amalgamated Wireless Australasia), the Australian contractor which had been awarded by the Australian Government's Department of Supply the contract to operate and maintain the Space Tracking Station to be built at Carnarvon in Western Australia for the National Aeronautics and Space Administration of the USA. Dench was employed at the tracking station for all eleven years that it was operation and in its last few years, before it officially closed in November 1974, Dench was the senior man at the station, the company manager (the manager for AWA on the station).

Paul Dench was born in England where he qualified as an electronics and telemetry engineer and worked for a number of years in those fields in the armed forces and private industry. In November 1962 he accepted a position in Australia with AWA which was unrelated to the Carnarvon project. It was not until April 1963, after he had arrived in Sydney, that he accepted the position of PCM (Pulse Code Modulation) senior engineer at Carnarvon. Four weeks later he and three other specialists flew out of Sydney to Wallops Island, Virginia, for four weeks advanced training in telemetry and digital command systems theory, followed by six weeks practical training on the operational equipment at the manufacturers' factories in Florida. This was the first of an extensive series of training courses, both at the station and in the USA, undertaken by station staff as new types of innovative equipment were installed at Carnarvon. Hardly had Dench returned to Sydney in 1963 than it was time to move with his wife and family to Carnarvon. As with all recruits from the UK the drive north from Perth was an unforgettable experience especially the 400km north from Geraldton and the arrival in Carnarvon.

Bringing the Carnarvon Tracking Station to operational readiness took less than a year. The official opening of the station was on 25 June 1964 but the station had already supported the unmanned Gemini 1 mission on 8 April. The first manned mission, Gemini 3, was flown in March 1965 but planning for the Apollo moon-landing project had by then already begun. A new generation of telemetry equipment was to be used for the Apollo project, the Unified S-band (USB) system. Dench was promoted to USB supervising engineer and he and the future USB team flew to Dallas, in July1965, for three months training at Collins Radio Company on the first USB system ever assembled, which was shortly to be shipped to Carnarvon. The tracking station's first mission to have USB support was the unmanned Apollo 2 in 1967, the first mission after the Apollo1 disaster at the beginning of the year.

In 1967 the technical staff of the tracking station was restructured into two groups, the Tracking System Group and the Communications Group. Dench was appointed supervising engineer of the Tracking System Group which consisted of the USB System, the FPQ-6 Precision Radar and the Goddard Range and Range Rate System which supported a diverse range of 36 different scientific satellites. The formation of the two groups was to facilitate the movement of technicians within the group to increase their skills and promotional opportunities. The following year Dench was appointed chief engineer of the station and, in January 1971, when the company manager was transferred to a Canberra tracking station, Dench replaced him as Carnarvon company manager.

On 4 May 1972 Dench had the unenviable task of announcing to the assembled trackers that operations at the station would be phased out by the end of 1974. General opinion at the station was that the Department of Supply had given preference to the ACT tracking stations despite the superiority of Carnarvon's geographical location and of the efficiency of its staff. The station's official closing ceremony was held on 6 November 1974.

11.0 ACKNOWLEDGEMENTS

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Mr Paul Dench
AWA Company Manager Carnarvon.

Ms Sabrina Dowling Guidici

Photographs and Diagrams

Engineers Australia thank the following people for the use of their photographs in this document

Paul Dench 8.3,9.7
Jim Gregg B6
Sabrina Dowling Guidici 6.3,6.4
David Johns B7
Terence Kierans front top right, front bottom left, B3, B4
Hamish Lindsay 6.2, 9.3
Tom Sheehan 6.1
Engineers Australia thank NASA for the use of the other photographs and diagrams in this document.

12.0 REFERENCES

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Carnarvon and Apollo, by Paul Dench and Alison Gregg, published 2010

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Biographical notes on astronauts and politicians contain some information obtained from Wikipedia.

Information for the biographical notes on Paul Dench is from *Carnarvon and Apollo* by Dench and Gregg.

APPENDIX A

Foreword in book Carnarvon and Apollo

by Dr Ken Michael, former Governor of Western Australia

In 1961, when President John Kennedy committed the United States to the challenge of 'landing a man on the moon and returning him safely to earth' by 1970, few would have believed that Australia would, or could, play a crucial role in this project; or that the Western Australian town of Carnarvon would become a location vital to this historic undertaking.

Australia's significant contribution to the Apollo program and the unlikely story of how a small port on the north-west coast of Western Australia became, for a time, the home of the largest NASA space tracking station outside mainland USA, is detailed in *Carnarvon and Apollo: One giant leap for a small Australian town*. This story is more than just one of technological and engineering achievement; it is also a story of the social impact on a rural town of the influx of an urban high-tech workforce.

The opening of the Carnarvon NASA Tracking Station in 1964 markedly changed a quiet town that had for many years relied on the pastoral, fishing and horticultural industries to sustain it. The establishment of the NASA facility brought to Carnarvon highly-qualified engineers and technicians, many with young families, who threw themselves whole-heartedly into community life. In the lulls between missions there was time for enthusiastic engagement in local community associations and sporting activities. The growth in Carnarvon's population also led to more schools, more services and upgraded facilities for all its residents.

As the Carnarvon Tracking Station became established as a crucial component on NASA's worldwide tracking network, high-tech met the outback using the Australian 'can-do' attitude to great effect. The need to provide improved telecommunications for the tracking station also led to Australia's first OTC satellite-earth station being built in Carnarvon. This facility helped to overcome the tyranny of distance by providing better communications to Perth and Western Australia as a whole. The first ever live television from Australia to the outside world came from the streets of Carnarvon and, later, Carnarvon brought that first step on the Moon to Western Australian audiences.

This book is not just a retelling of the 'man on the moon' story. It tells of the close relationship between the town and its tracking station and the impact of each on the other. The 'tracker families' and the Carnarvon community at large remember those times, deservedly, with a great deal of pride and satisfaction.

GOVERNOR

APPENDIX B

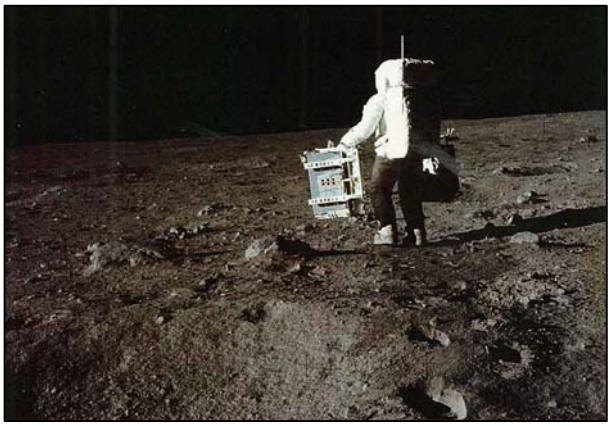

Figure B1. Astronaut Buzz Aldrin laying out the EASEP equipment, which CRO later switched on.

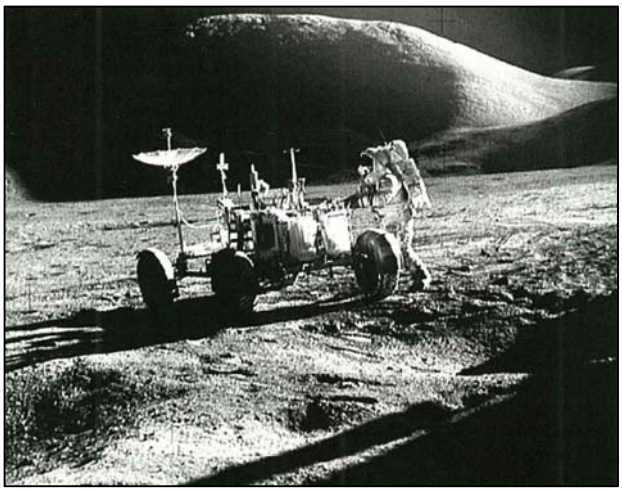

Figure B2. Just beyond the shadow of LEM, astronaut Jim Irwin with the Lunar Rover.

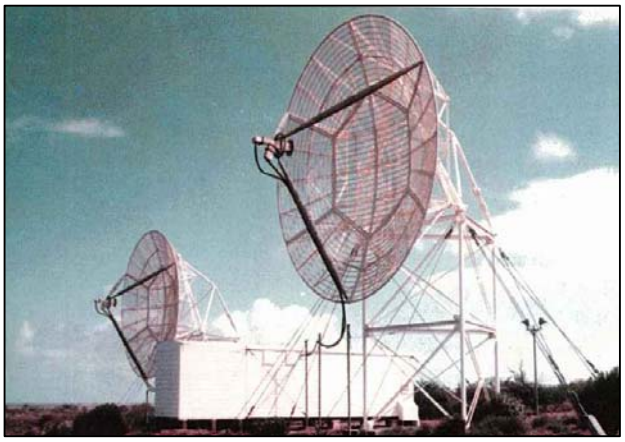

Figure B3. Troposcatter dishes pointing towards Geraldton.

Figure B4. SPAN Radio Telescope, front, with the optical telescope building behind

Figure B5. Assembly of the FPQ-6 radar dish

Figure B6. A balloon about to be released for a FPQ-6 track.

Figure B7. Dismantling CRO starts with the removal of the FPQ-6 radar dish

APPENDIX C

List of Acronyms

CRO	Carnarvon Tracking Station – call sign
EASEP	Early Apollo Scientific Experiments Package
EAS	European Space Agency
FPQ-6	FPQ-6 radar
GRARR	Goddard Range and Range Rate
MSFN	Manned Space Flight Network
NASA	National Aeronautics and Space Administration
OTC	Overseas Telecommunications Corporation
SPAN	Solar Particle Alert Network
STADAN	Satellite Tracking and Data Network
STDN	Spaceflight Tracking and Data Network
T&C	Telemetry and Control
TDRS	Tracking and Data Relay Satellites
TLI	Trans Lunar Insertion
TTC&M	Tracking, Telemetry, Command & Monitoring
TT & C	Tracking, Telemetry and Control
VERLORT	Very Long Range Tracking Radar
VHF	Very High Frequency
WRESAT	Weapons Research Centre Satellite