History of Rocketry and Astronautics

Proceedings of the Fifty-Second History Symposium of the International Academy of Astronautics

Bremen, Germany, 2018

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AAS History Series, Volume 51

A Supplement to Advances in the Astronautical Sciences

IAA History Symposia, Volume 38

AAS Publications Office
P.O. Box 28130
San Diego, California 92198

Affiliated with the American Association for the Advancement of Science
Member of the International Astronautical Federation

First Printing 2021

ISSN 0730-3564

ISBN 978-0-87703-677-7 (Hard Cover Plus CD ROM)
ISBN 978-0-87703-678-4 (Digital Version)

Published for the American Astronautical Society
by Univelt, Incorporated, P.O. Box 28130, San Diego, California 92198
Web Site: http://www.univelt.com

Printed and Bound in the U.S.A.

Chapter 20

The Dish Was Not the Whole Story: Australia's Role in Apollo 11 Television from the Lunar Surface*

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Abstract

The Australian film *The Dish* (2000) brought to public attention, both in Australia and internationally, the crucial role that the Parkes Radio Telescope played in bringing the live television broadcast of the Apollo 11 lunar landing to the world. While factually based, the film's focus on Parkes presented only one slice of the significant role played by space tracking and satellite communications facilities in Australia in receiving and broadcasting lunar surface television from Apollo 11 and later landing missions.

This chapter will outline the role played in the Apollo 11 and later lunar surface television broadcasts by the NASA Manned Spaceflight Network stations in Australia, with the support of the NASA Deep Space Tracking Station at Tidbinbilla (near Canberra), the Parkes Radio Telescope, and the satellite communications facilities of the Overseas Telecommunication Commission, which managed all international communication into and out of Australia. It will discuss some of the technical issues faced by the Australian stations in dealing with the

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* Presented at the Fifty-Second Symposium of the International Academy of Astronautics, October 1–5, 2018, Bremen, Germany. Paper IAC-18-E4.3B.11.

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different US television system and highlight the role that the Apollo program played in hastening the advent of satellite communications into Australia.

I. Introduction

Released in 2000, the Australian film *The Dish* (Working Dog Productions)[1] was a gentle comedy that explored 1960s life in the small New South Wales country town of Parkes, against the background of the involvement of the nearby 64-meter radio telescope operated by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in the Apollo 11 Moon landing. The film highlighted the crucial role played by the Parkes Radio Telescope in bringing to the world the live television broadcast of the first lunar landing. However, the events depicted in this film, while factually based,[2] glossed over the of the significant role played by the Australian stations of NASA's Manned Spaceflight and Deep Space Networks[3] and the satellite communications facilities of Australia's Overseas Telecommunications Commission (OTC),[4] in receiving from the Moon and broadcasting to the world the lunar surface television from Apollo 11 and later landings. This chapter, therefore, aims to correct the erroneous impression created by *The Dish* and present the whole story of Australia's role in the bringing lunar surface television from the Apollo missions to the world.

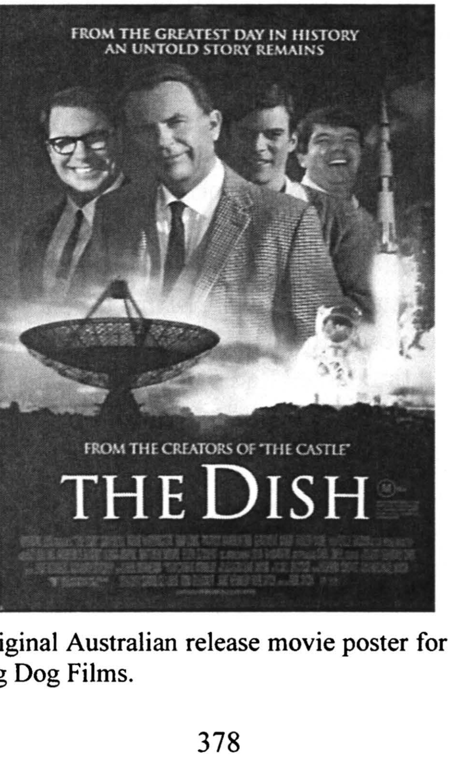

Figure 20–1: Original Australian release movie poster for *The Dish.* Credit: Working Dog Films.

II. Partners in Space: NASA and Australia

Australia's participation in the Apollo program was not, as the film implies, a matter of expedience: rather it was a continuation of the space tracking partnership between NASA and the Australian Government that had commenced in 1960.* As a stable Southern Hemisphere democracy allied with the United States, Australia was well-placed, politically and geographically[5] to partner with NASA in the development of its three global tracking systems: the Deep Space Network (DSN) for robotic planetary exploration; the Space Tracking and Data Acquisition Network (STADAN) for Earth orbiting satellites and the Manned Space Flight Network (MSFN) supporting human spaceflight.

Under the terms of the "Space Cooperation Agreement"† signed on 20 February 1960, NASA was responsible for policy, system design and financing the construction and operation of its tracking stations. Australia undertook the detailed facilities design and the installation, staffing, operation and maintenance of the stations. This included providing land, access roads and utilities connections for the station sites.

On NASA's behalf, the Australian stations were managed during the Apollo period by the Department of Supply, through its agency the Weapons Research Establishment (WRE), based in South Australia.‡ Initially, the WRE directly managed and staffed the tracking stations. However, in 1962, it established the American Projects Division to oversee its tracking station responsibilities,[6] while the daily operation of the stations was contracted to private industry, employing local staff.[7] In 1968, with NASA facilities now concentrated around Canberra, this office was transferred to the Department of Supply's Canberra headquarters.[8] To oversee its interests in Australia, NASA established its own liaison office in Canberra in 1962, initially staffed by a Senior Scientific Representative and a representative of the Jet Propulsion Laboratory (JPL), overseeing Deep Space

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* US satellite tracking stations were first established in Australia in 1957, for the planned Vanguard satellite program. They were transferred to NASA on its establishment, with the arrangements formalised in 1960.

† The full title of the agreement was *Exchange of Notes Constituting an Agreement between the Government of Australia and the Government of the United States of America Concerning Space Vehicle Tracking and Communication Facilities* (Australian Treaty Series 1960, no. 2). The management policy it established has enabled the Australia-NASA space tracking partnership to continue up to the present day. In 2018, the Agreement was renewed for a further 25 years. See *National Interest Analysis* [2017] ATNIA 30
http://www.austlii.edu.au/ au/other/dfat/nia/2017/30.html (accessed 15/9/2018).

‡ The WRE's primary responsibilities lay in defense science research, including the management of the Woomera Rocket Range. As the earliest pre-NASA US tracking stations were located at Woomera, the WRE assumed responsibility for space tracking by default.

Network operations in Australia.[9] By the time Apollo flights commenced, a representative from the Goddard Space Flight Center was also stationed in the office, overseeing MSFN and STADAN activities.[10] Thus, by July 1969, Australia had become a vital part of NASA's space tracking infrastructure, hosting the largest number of tracking facilities outside the United States.[11]

III. Australian Tracking Stations Supporting the Apollo Program

Of the six major NASA facilities in Australia in 1969, four were directly involved in supporting the Apollo program. These stations were:

III.1. Carnarvon (MSFN/STADAN)

Officially opened in June 1964,* the Carnarvon station (callsign CRO) was located near the isolated tropical coastal town of Carnarvon, Western Australia. Initially established as a MSFN station to support the Gemini missions, Carnarvon was also equipped as STADAN facility, tracking NASA scientific satellites. This dual MSFN/STADAN role made Carnarvon the largest NASA tracking facility outside the United States. In 1966, Carnarvon was upgraded to track the planned Earth-orbiting Apollo missions and support the near-Earth phases of lunar missions: in an emergency Carnarvon could even support lunar operations. The station was also crucially positioned to provide the go/no go confirmation for Lunar Orbit Insertion, the rocket engine burn that would send an Apollo spacecraft out of Earth orbit and on its way to the Moon.

Also based at the Carnarvon station was an observatory for NASA's Solar Particle Alert Network (SPAN). Established in 1967, the three SPAN observatories (the other two were located at NASA's Johnson Space Center in Houston and in the Canary Islands) maintained a 24-hour watch on the Sun to ensure that spaceflights, especially lunar missions, were not launched during dangerous periods of solar activity.

During Apollo, Carnarvon received data from the EASEP and ALSEP experiments (Early Apollo Surface Experiment Package and Apollo Lunar Surface Experiment Package) left on the Moon by Apollo 11 and subsequent lunar missions. With completion of the Apollo program, the station would support the Skylab space station program (1973–1974) before being closed in 1975, made redundant by the hiatus in US human spaceflight between Skylab and the Space Shuttle.

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* Carnarvon replaced an earlier Mercury Space Flight Network station at Muchea, near Perth, Western Australia, which was too far south to effectively track Gemini missions.

Figure 20–2: Aerial view of the main building at the Carnarvon MSFN/ STADAN station. To the right of the building is the 9-m dish installed for tracking Apollo missions. Further to the right, the twin antennae of the tropospheric scatter radio link to the town of Geraldton can be seen. Credit: Hamish Lindsay.

III.2. Tidbinbilla (DSN)

Deep Space Station (DSS) 42, was NASA's second DSN facility in Australia,* located in the Tidbinbilla Valley, about 40 kilometers from the national capital, Canberra. Commencing operations in 1964, the station (callsign TID) was initially equipped with a 26-meter polar-mounted antenna. However, by the end of the Apollo program it would also boast a 64-meter antenna, whose design was based on that of the Parkes Radio telescope, as will be discussed below.

Because the Apollo missions planned to use the lunar-orbit rendezvous technique, it meant that the MSFN would have to simultaneously monitor two spacecraft operating independently during lunar landing missions (the Command Module, which would remain in orbit, and the Lunar Module, located on the Moon's surface). The DSN contributed a great deal of technology to the Apollo program, which used DSN computer software for lunar trajectory and orbit determination purposes and also adopted the S-Band communications system de-

* The first Deep Space Network station in Australia was DSS-41, established at Island Lagoon, near the Woomera Rocket Range. It was operational from 1961–1972.

veloped by the Jet propulsion Laboratory (JPL).[12] This meant that similar equipment was employed at both MSFN and DSN stations. NASA therefore decided to employ its DSN stations as adjuncts to the MSFN: the DSN station would control one lunar spacecraft, while the MSFN station handled the other.

Tidbinbilla was consequently "twinned" for Apollo lunar missions with a new MSFN station established at Honeysuckle Creek (see below). The two stations were linked by microwave relay and a second control room, known as the "MSFN wing," was added at Tidbinbilla, enabling it to function as a second receiving and transmitting station for Honeysuckle Creek.[13]

At the end of the Apollo program, Tidbinbilla continued its deep space tracking role and, under the name Canberra Deep Space Communications Complex, remains in operation today. The last major NASA facility in Australia today, Tidbinbilla still forms a vital part of the Deep Space Network.

Figure 20–3: Deep Space Station 42 Tidbinbilla was the Apollo program "twin" for the Honeysuckle Creek MSFN station. This view of the station shows the new "MSFN wing" added for the Apollo missions and the microwave link to the Honeysuckle Creek station in the foreground. Credit: Hamish Lindsay.

III.3. Honeysuckle Creek (MSFN)

To prepare for Apollo, NASA established three new MSFN stations, each equipped with a 26-meter antenna to handle the translunar and lunar phases of the Moon missions. These stations were located in proximity to the three Deep Space Network stations so that, as noted above, the DSN facilities could work in conjunction with the MSFN stations.[14] The Australian MSFN Apollo station, opened in 1967, was Honeysuckle Creek (callsign HSK).

Located on a mountain top approximately 15 kilometers south of Tidbinbilla, HSK's first mission was the unmanned Apollo 4, after which it would go on to support every Apollo flight until the end of the program, as well as receiving data from the ALSEP experiment packages left on the Moon by each landing mission. As will be outlined in detail below, Honeysuckle Creek would be the station that brought the television signals of Armstrong's first step onto the lunar surface to the world. After supporting the Skylab space station program, in 1974 Honeysuckle Creek was transferred to the DSN (as DSS-44): control of the facility was transferred to Tidbinbilla, in a reversal of the Apollo-era relationship.

Although the station was closed in 1981, the historic HSK antenna was relocated to Tidbinbilla in 1983, where it was redesignated DSS-46, providing communication and tracking for Space Shuttle missions. In 1986, following the closure of the Orroral Valley STADAN station, it also took over Earth satellite tracking operations until NASA's Tracking and Data Relay Satellite System came into operation: this system ultimately rendered the MSFN and STADAN networks redundant.

The HSK antenna remained in operation at Tidbinbilla until 2009, supporting NASA and international deep space missions. A few months after the 40th anniversary of the Apollo 11 landing, it was formally retired to become an engineering heritage monument.[15]

III.4. Orroral Valley (STADAN)

The fourth Australian facility supporting Apollo was Orroral Valley STADAN station (callsign ORR). Replacing an earlier STADAN station at Woomera, the second-generation Orroral Valley facility was located close to the Honeysuckle Creek station (and eventually connected to it via a microwave link). Opened in 1966, Orroral's primary role was to support Earth orbiting spacecraft. However, like Carnarvon and Honeysuckle, the Orroral station was used to receive data from the ALSEP instruments left on the Moon. Orroral later provided communication and tracking for the 1975 Apollo-Soyuz Test Project (the first space linkup between the Soviet Union and the United States) and early Shuttle missions, before being closed in late 1985.

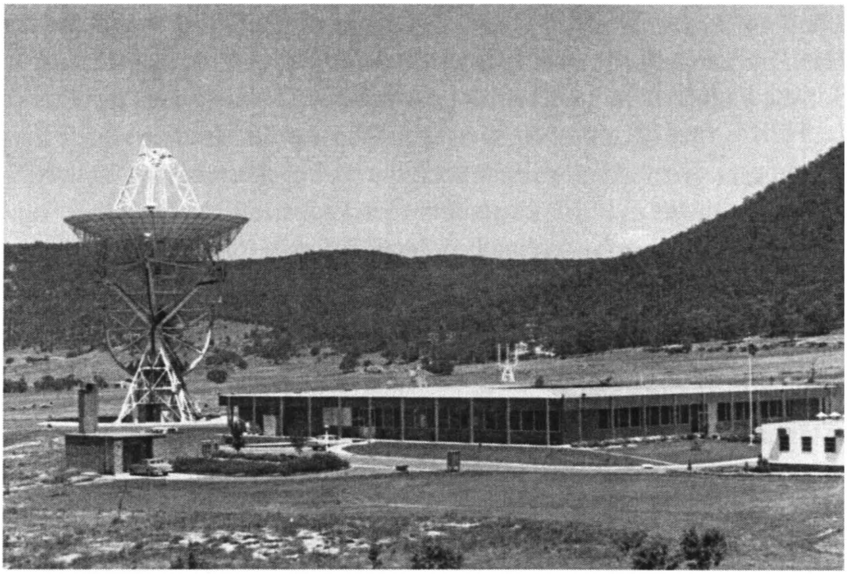

Figure 20–4: Orroral Valley STADAN station in 1969, showing the operations Building and 26-m antenna. Orroral received data from the ALSEP instrument packages left on the Moon by the Apollo missions. Credit: Ted Barnes.

IV. The Parkes Radio Telescope and NASA

Located near the small town of Parkes, about 350 kilometers west of Sydney, the Parkes Radio Telescope is one of the world's major radio astronomy research instruments. Opened in October 1961, the 64-meter fully steerable antenna was designed and operated by the Commonwealth Scientific and Industrial Research Organisation (CSIRO).[16]

Early experience in tracking the first US lunar probes in the late 1950s led JPL to consider augmenting its initial DSN network of 26-meter dishes with tracking antennas in the 64-meter class. The tracking capabilities that JPL required of these large antennas approximated closely with those of the Parkes Radio Telescope: its master equatorial precision pointing system* also provided the level of pointing accuracy that the DSN required in order to maintain contact with distant spacecraft. These factors encouraged JPL to consider the Parkes Ra-

* This system was designed by the British engineer Barnes Wallis, famous as the designer of the World War 2 "dam busters" bouncing bombs.

dio Telescope as the prototype for the antennas of its second-generation network.*

Consequently, while its own 64-meter antennas were under development, NASA made several approaches to the CSIRO to have the Parkes facility formally included in the DSN. Although the telescope's full schedule of astronomical research meant that the CSIRO declined these offers, the organization collaborated with JPL on the development of their antennas, establishing a good working relationship between the two institutions that proved to be of critical worth when Parkes' supported future space missions.[17]

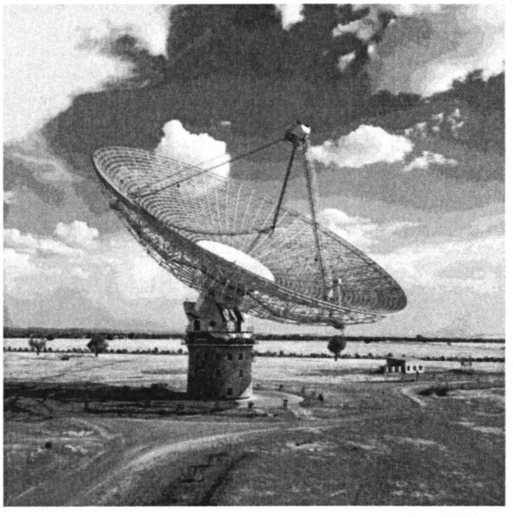

Figure 20–5: The Parkes Radio Telescope in the early 1960s. This radio astronomy instrument became the prototype for the 64-m antennae of NASA's Deep Space Network. Credit: CSIRO.

To demonstrate the Parkes antenna's capabilities for deep space communications, and provide valuable tracking experience for the telescope's staff, the CSIRO participated in tracking the Mariner 2 space probe as it approached and flew past Venus on the world's first successful planetary mission. Parkes also tracked the Mariner 4 Mars mission, as a backup to Tidbinbilla and received the data for the 22 images the spacecraft obtained of the Martian surface. The higher gain of the Parkes antenna meant that when its data was combined with that captured by the 26-meter DSN antennas, the result was a considerable improvement in the quality of the pictures of the Martian surface.[18]

* Despite its greater size, the 64-meter radio telescope was built at a significantly lower cost than the contemporary 26-meter DSN antenna at Island Lagoon. This cost saving also apparently attracted JPL's interest.

During a visit to the United Sates in October 1968, Parkes Director John Bolton was requested to make the radio telescope available during the most critical phases of the Apollo 11 mission, when the Lunar Module (LM), *Eagle*, was on the lunar surface. NASA had realized that, all going to plan, the first Moon landing would occur near the end of the "view period" from its Goldstone DSN station. Parkes would consequently be well-placed to provide backup support for Honeysuckle Creek and Tidbinbilla for most of the first Moonwalk. Recognizing the historic nature of the Apollo 11 mission, and aware that the astronaut's lives could be at risk, Bolton was so eager to assist NASA that he established a simple agreement which literally said that "Parkes would do everything necessary to support the Apollo 11 landing."[19]

V. NASA's Role in the Introduction of Satellite Communications to Australia

Prior to the advent of satellite communications, the early NASA facilities in Australia maintained contact with the United States via teletype and leased HF radio circuits provided by the Overseas Telecommunications Commission (OTC). OTC managed Australia's overseas communications, while the Postmaster General's Department (PMG) was responsible for Australia's domestic communications, including postal, telephone and telegraph services. Regular teletype traffic from the Woomera DSN and STADAN stations was handled by a special NASA communications network (NASCOM) switching center in Adelaide, provided by the PMG. With NASA facilities concentrated in the ACT by the time of Apollo 11, the Adelaide facility had been replaced by a NASCOM switching center at Deakin, in Canberra.

However, from the outset the remote location of the Carnarvon MSFN station posed special challenges in communicating with the United States: the telephone lines that served the town were only marginally reliable for data transmission. After a lightning strike damaged the phone lines connecting Carnarvon to Perth (the state capital), almost rendering the station unable to support its first official mission in April 1964,* NASA attempted to improve reliability by installing a tropospheric scatter radio link to the town of Geraldton, which had bet-

*After the lightning strike, PMG technicians worked frantically to improvise an alternative route around the damaged section of line, utilizing an obsolete pole-top phone line. The postmistress at the tiny community of Hamelin Pool then read the data figures received from Perth along this line to the Carnarvon Telephone Exchange for more than two hours. The full story of this incident can be found at https://honeysucklecreek.net/other_stations/carnarvon/index.html (accessed 18/9/18).

ter telecommunications links to Perth. However, this link only functioned well in cloudy weather.[20]

Carnarvon's communication difficulties contributed to NASA's 1965 decision to utilize satellites for the Apollo project, thus ensuring reliable communications between its global tracking station network and Mission Control in Houston.[21] NASA contracted INTELSAT, the international consortium at that time establishing the world's first global satellite communications system, to supply, launch and operate two geostationary satellites for Apollo communications: these would become the INTELSAT II series, with one satellite operating above the Pacific Ocean, and the other servicing the Atlantic and Indian Oceans.[22]

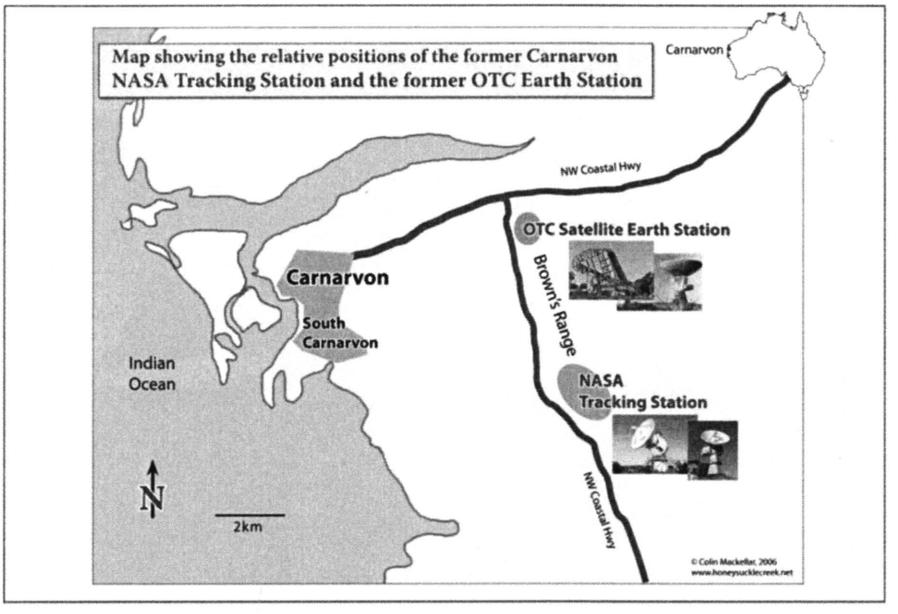

Figure 20–6: Map showing the location of the Carnarvon MSFN/STADAN station and the OTC Satellite Earth Station that was built nearby, to connect the NASA facility to the United States via an INTELSAT II satellite. Credit: Colin Mackellar www.honeysucklecreek.net.

Unable to connect directly to these satellites, NASA tracking facilities needed satellite ground stations in close proximity in order to utilize the satellite network. Although Australia was a founding member of INTELSAT, and would become its sixth largest shareholder, a decision had not yet been made on where and when Australia would establish its first satellite ground station. Therefore, when NASA requested that OTC, as Australia's INTELSAT representative, provide a ground station to secure reliable communications for the Carnarvon facility, this dictated the location of Australia's first Satellite Earth Station.[23]

Located approximately 4 kilometers north of the Carnarvon MSFN station, the OTC station was linked to it by twin telephone lines: this enabled "circuits of voice between controllers in Australia and the United States as well as teleprinter links and data circuits between these points."[24] To meet NASA's operational requirements, the OTC station was planned to begin operations by October 1966: as the station's 'anchor tenant' NASA and OTC negotiated a three-year contract that ensured support services to the US space program until 30 September 1969.[25]

A fortuitous circumstance enabled the first satellite broadcast from Australia, *Down Under Comes Up Live*, a co-production between the Australian Broadcasting Commission (ABC) and the BBC, to be transmitted to the United Kingdom on 25 November.[26] Operational support for NASA commenced on 4 February 1967, linking to INTELSAT's Pacific Ocean satellite, followed soon after by commercial operations.[27]

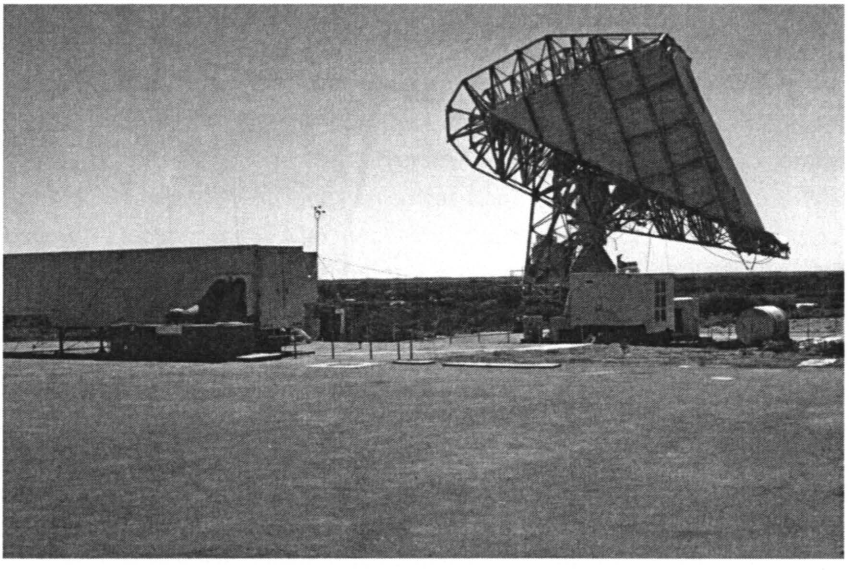

Figure 20–7: The unusual Cassegrain folded-horn antenna constructed at the Carnarvon OTC station in 1966, with its support vans. This antenna enabled the first satellite television transmission from Australia in November 1966. Credit: John Lambie.

To meet the growing demand for satellite access, in March 1968 OTC opened a second Satellite Earth Station in Moree, NSW, linking to INTELSAT's Pacific satellite. OTC's third ground station at Ceduna, South Australia, became operational in 1969, linking to the INTELSAT III Indian Ocean satellite. Through these facilities, OTC would provide approximately 90 percent of the international communications links in the Southern Hemisphere during the Apollo missions.[28] Tracking ships and Apollo Range Instrumented Aircraft (ARIA) in the Asia-Pacific region, which provided communications links when a spacecraft was out of contact with land-based tracking stations, also relayed their data via the Australian OTC facilities. NASA CRO and OTC Carnarvon continued to work in conjunction on NASA space programs until the closure of the NASA station in 1975 ended the foundational association between OTC and NASA that had brought the first satellite communications to Australia.*

VI. Planning for Apollo Lunar Surface Television

While providing television coverage of the lunar landings seems today an obvious step to take, NASA had not originally intended for the first Moon landing to be televised live, preferring instead to use the relatively low-bandwidth signal from the Lunar Module for telemetry (particularly astronaut biomedical data) and radio commentary from Armstrong and Aldrin.[29] Despite a growing recognition of the public relations value for NASA of live television from space,[30] it was not until early 1969 that a final decision was made to include a direct television broadcast from the surface of the Moon, even though a camera for this purpose was already in development.[31]

The lunar surface television camera was developed by Westinghouse, which had already produced the black and white Command Module (CM) cameras used on Apollos 7–9 and the color camera used on Apollo 10 and in the Apollo 11 CM. As the weight of the Lunar Module (LM) was a critical factor in mission success, it was initially felt by NASA engineers that a television camera for lunar surface operations would be too bulky and heavy to be accommodated. However, the Westinghouse team delivered an extremely compact and relatively lightweight television camera that fit within the necessary parameters for it to be carried on the LM. It was, however, only for black and white transmission: a suitably compact color camera would not be available until Apollo 12.

Because the available bandwidth from the Moon (500kHz) was not sufficient for a standard TV signal, the Westinghouse camera provided a slow-scan black and white image, with a vertical resolution of 320 lines scanned at 10 frames per second. Once the signal was received on Earth, it would be converted back into an American-standard 525 lines, 30 frames per second signal for transmission to television broadcasters.

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* However, OTC Carnarvon's involvement with space exploration continued. From 1979, until its closure in 1987, the Satellite Earth Station would operate a European Space Agency tracking facility, constructed onsite.

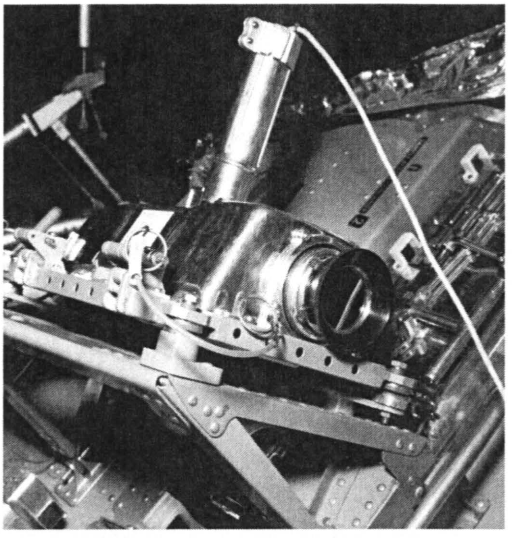

Figure 20–8: The Westinghouse Apollo 11 lunar surface camera mounted upside down on the MESA in the Lunar Module descent stage. Credit: NASA.

To capture Armstrong's first footsteps on the Moon, the camera was mounted upside down (its top being the only suitable flat surface for mounting) in the Modularized Equipment Stowage Assembly (MESA) in the LM descent stage, adjacent to the ladder on which Armstrong would descend to the lunar surface. As he exited the Lunar Module, Armstrong would deploy the MESA, which would swing out to allow the camera to view his descent: when Aldrin put in the TV circuit breaker, the vision would be broadcast to the Earth.

Once the astronauts were on the Moon, the camera could be removed from the MESA and placed on a stand to observe and broadcast the lunar surface operations.

VII. The Timelines for Apollo 11 Lunar Surface Television

The original mission plan for Apollo 11 allocated Parkes the role of backup to the 64-meter antenna at Goldstone for the reception of television during the Moonwalk, or lunar EVA, in the event of delays in the mission timeline. Goldstone would be the prime station for the television, while the 26-meter antenna at Tidbinbilla, with its slightly more sensitive MASER receiver, would track and communicate with the Lunar Module, which had a weaker signal, and receive telemetry from it.[32] The Honeysuckle Creek station was to track the Command

Module, *Columbia*, in lunar orbit at the same time. To facilitate its role, Parkes would be linked by microwave relay to Tidbinbilla and Honeysuckle Creek.[33]

As outlined in detail on the Honeysuckle Creek Tracking Station tribute website,[34] the initial flight plan had the astronauts performing the Moonwalk shortly after landing, anticipated at around 06.00 Australian Eastern Standard Time (AEST). As the Moon was not due to rise at Parkes until 13:02 (AEST), if all went to plan, the EVA would have been completed by that time.

Two months before the Apollo 11 mission, these plans changed when it was decided to alter the schedule and allow the crew a rest period before commencing the lunar EVA: this would give the astronauts time to adjust to the lower lunar gravity and start their Moonwalk refreshed. The new plan scheduled the commencement of the EVA about ten hours after landing, at 16:21 (AEST). This was about twenty minutes after the Moon had set for the Goldstone. At this time the Moon would be high overhead at Parkes, so the radio telescope's role was consequently upgraded from backup to prime receiving station for the television broadcast of the EVA.

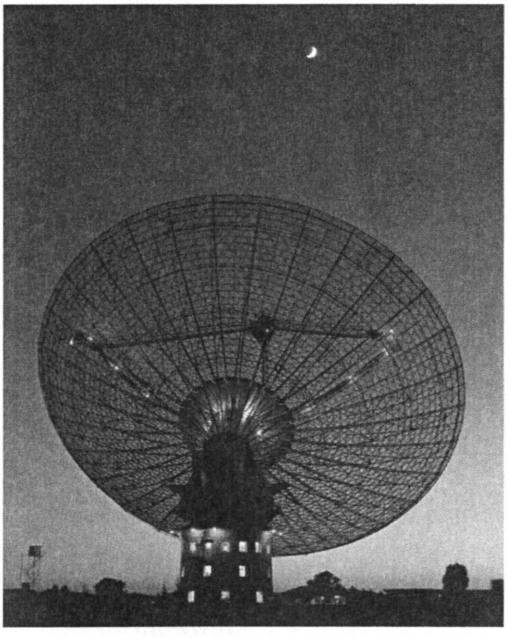

Figure 20–9: The Parkes Radio Telescope pointed toward the Moon during a rehearsal for the Apollo 11 landing. Credit: CSIRO.

One day after the launch of Apollo 11, a fire in the power supply at Tidbinbilla severely damaged the transmitter. Although the damage was repaired within 12 hours, NASA decided to switch roles between Tidbinbilla and Honeysuckle Creek: the latter would now concentrate throughout the Moonwalk on the vital telemetry data from the crew's backpack EVCS (Environmental Control System), while Tidbinbilla maintained communication with the Command Module in lunar orbit.[35]

VIII. Apollo 11 Television: From the Moon to the World via Australia

On Monday 21 July 1969, at 06:17 (AEST), Armstrong and Aldrin landed on the Sea of Tranquillity in their LM *Eagle*. Despite the rest period built into the flight plan, mission commander Neil Armstrong exercised his option for an immediate Moonwalk. This was five hours before the Moon was due to rise at Parkes, returning the television prime role to Goldstone. However, delays in the astronauts' preparation for their EVA brought the time of LM egress closer to that of Moonrise at Honeysuckle and Parkes.[36]

During this period, a violent wind squall struck the Parkes region. Fully tipped over to its zenith axis limit, waiting for the Moon to rise and ready to receive the images and telemetry from the Moon, the Parkes dish was extremely vulnerable to damage in the severe weather conditions. Two sharp gusts of wind exceeding 110 kph struck the dish, subjecting the antenna to wind forces ten times stronger that it was considered safe to remain operational: the dish should have been stowed in its less vulnerable vertical attitude. The weather remained dangerous at Parkes, with the telescope operating well outside safety limits for the entire duration of the Moonwalk. Fortunately, however, the winds abated somewhat as the Moon rose, just as Aldrin activated the TV at 12:54:00 (AEST).[37]

As Armstrong began his descent to the lunar surface, three tracking stations were receiving the signals from the LM simultaneously: Honeysuckle Creek, Goldstone and Parkes. Although the Moon had not yet risen high enough for the signal to be received by its main feed, a less-sensitive "off-axis" detector at Parkes was able to pick up the lunar signal just as the LM TV camera was switched on.[38]

The signals from Parkes* and Honeysuckle Creek were sent to Sydney via microwave links specially installed by the PMG. At OTC's Sydney switching facility a NASA technician selected between the Parkes and Honeysuckle Creek signals to be relayed to Houston for inclusion in the international telecast. The selected signal was then sent via cable to the OTC Satellite Earth Station at Mo-

* The telemetry from the LM was also being received at Parkes and this was split off from the television signal and sent to HSK, while the television feed was sent directly to Sydney.

ree for transmission to the United States via the INTELSAT III F4 satellite. The signals were received at the Jamestown ground station in California and then sent by landline to the Manned Spacecraft Center in Houston, where a controller then selected between the Goldstone signal and the previously selected Australian TV signals.[39]

Figure 20–10: Apollo television links from the receiving stations in Australia to the United States. Credit: Hamish Lindsay.

Research by both John Sarkissian[40] and the former trackers who contribute to the Honeysuckle Creek Tracking Station tribute website[41] has established that during the first nine minutes of the broadcast, NASA alternated between the signals from its two stations at Goldstone and Honeysuckle Creek, searching for the best quality images. They began with the Goldstone pictures: however, due to an incorrect scan conversion setting, the image was poor and suffered from severely high contrast. It was also initially upside-down, because a technician at Goldstone had forgotten to operate the switch that inverted the signal from the camera, which was upside-down on the MESA. The Honeysuckle Creek pictures were very grainy due to the low signal strength received by the smaller dish, but they were nevertheless better than the images from Goldstone and it was Honeysuckle Creek's images that were transmitted to the world when Neil Armstrong took that "one giant leap for mankind."

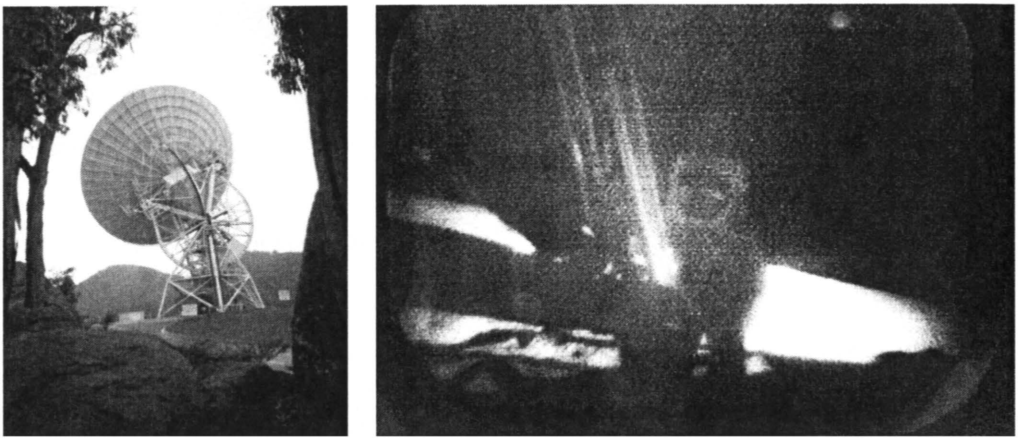

Figure 20–11: Left: Honeysuckle Creek tracking station. This photo was taken just as the television signals of Armstrong's first step on the Moon were being received. Credit Hamish Lindsay. Right: Honeysuckle Creek video seen around the world, showing Armstrong on the lunar surface. Credit: www.honeysucklecreek.net.

Eight minutes into the broadcast, the Moon had risen into the field of view of the Parkes telescope's main detector. Its signals provided superior picture quality and, at 8 minutes and 51 seconds into the broadcast, Houston switched to the transmissions from Parkes and remained with the Parkes television for the remainder of the 2½ hour telecast.

Figure 20–12: The control room at the Parkes Radio Telescope during the Apollo 11 Moonwalk. Live television from the Moon is being received on the monitor in the background. Credit: CSIRO.

NASA provided its television feed from Houston directly to the US television networks and internationally via satellite. The Australian public, however, saw the lunar TV directly, rather than via Houston, as the TV from Sydney was split, with one signal going to OTC Moree and another to the Sydney studios of the Australian Broadcasting Commission (ABC). Using a locally built scan converter to produce a 625 line/50 frames per second Australian-standard version, the ABC also provided their feed to the local commercial networks. Australian viewers therefore saw the first Moonwalk fractionally before the rest of the world.[42]

The only exception to this was Western Australia, which had no direct microwave connection to the eastern states. Instead, the signal from OTC Moree was also sent back from INTELSAT III F4 to OTC Carnarvon, from whence it was sent over a just-installed landline to Perth, and then broadcast to those parts of Western Australia which had television service.*

It has been estimated that six hundred million people, or one fifth of humanity at the time, watched Neil Armstrong's first steps on the Moon, courtesy of Honeysuckle Creek and the Parkes Radio Telescope.

After the Moon landing, NASA Administrator Thomas O. Paine, sent a message of commendation to the Australian Minister for Education and Science, Malcolm Fraser:

> I wish to express my sincere appreciation to you and the Commonwealth Scientific and Industrial Research Organisation for making available the Parkes facility during the Apollo 11 mission. Its participation, and spectacular performance, provided the entire world with a chance to experience, with astronauts Armstrong and Aldrin, this historic event.[43]

IX. Fuzzy Pictures: Some Apollo Television Technical Issues

The low quality of even the best Parkes television vision from the Moon was the result of several technical issues arising as the slow-scan signal from the Moon was converted and re-converted and then transmitted around the world via landline and satellite.

As noted above, logistical limitations imposed on the Westinghouse Apollo 11 lunar surface camera meant that it could only transmit a low quality slow-scan image. When the signal was received back on Earth, specially built scan converters at Goldstone and Honeysuckle Creek turned the signal into the American tel-

* The town of Carnarvon itself did not have a television service at this time and special arrangements were made to provide a feed into the town so that the Moonwalk could be viewed live locally.

evision standard. The Parkes slow scan TV signal was sent directly to the OTC Paddington gateway exchange in Oxford Street, Paddington, Sydney, and converted to the US television standard there before being selected and transmitted to the United States.[44]

Although the local Australian television feed was then re-converted to the Australian television standard, surviving clips from the Sydney broadcast show that the images seen on Australian television were still better than those seen in the international broadcast. Photographs and home movie footage taken at Parkes and Honeysuckle Creek also provide evidence that the slow-scan signal as received from the Moon was noticeably clearer than the final broadcast images.[45]

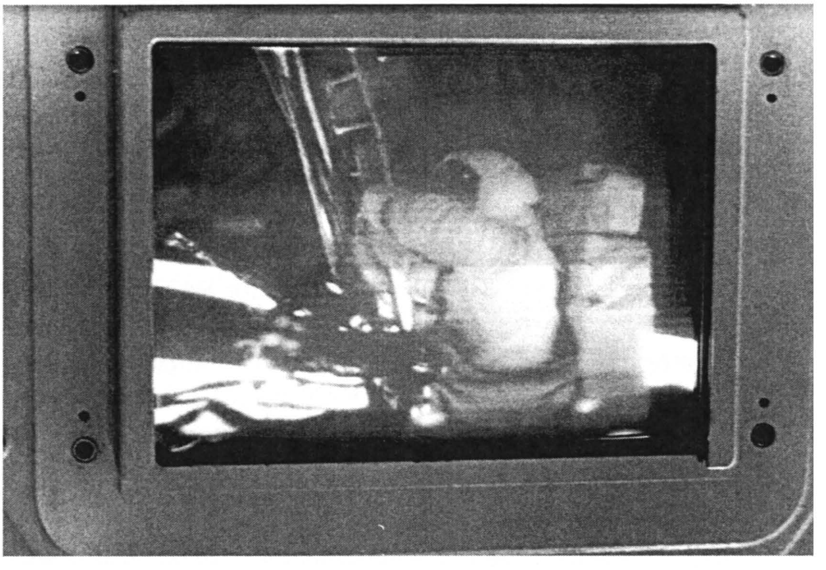

Figure 20–13: Photograph of the slow-scan monitor at Honeysuckle Creek, showing the quality of the unconverted television being received directly from the Moon. A series of images comparing the unconverted slow-scan images with the broadcast images from Honeysuckle Creek, Parkes and Goldstone can be found on the www.honeysucklecreek.net website.
Credit: www.honeysucklecreek.net.

Scan conversion and transmission via landline and satellite each introduced a level of degradation to the signal, so that the final vision seen on the world's televisions did not represent the real quality of the images received from the Moon. It was for this reason that attempts were made in the early 2000s to locate the original Apollo 11 telemetry tapes, in the hope that the original television signals could be extracted from the tape, to produce a greatly improved television recording of the first Moonwalk. This search eventually proved unsuccessful, but its conduct will form the subject of a future paper.

X. Australian Participation in Lunar Surface Television for Later Apollo Missions

With the lunar surface television network fully in position and tested with the success of Apollo 11, Tidbinbilla and Honeysuckle Creek went on to support the Apollo 12 Moon landing, in November 1969, with the Parkes Radio Telescope once again contracted to provide telemetry and television support for the Lunar landing. Parkes was receiving the lunar television at the time when astronaut Alan Bean accidentally burned out the new Westinghouse color television camera by pointing it directly at the Sun.[46] When lunar landings recommenced after the Apollo 13 emergency, Honeysuckle Creek and Tidbinbilla continued to play a role in the lunar missions, receiving telemetry from the LM and CM, with Parkes continuing to provide telemetry backup for Apollos 14, 15, and 17.[47] Mission scheduling meant that lunar surface television was received primarily at Goldstone for Apollo 14, 16, and 17, but Honeysuckle Creek and Parkes, played a major role in the reception of lunar surface television for Apollo 15.[48]

XI. Conclusion

Despite the enjoyable portrayal of the story of Apollo 11 lunar surface television in *The Dish*, this chapter has shown that the real story of enabling the world to share, live, in one of the most significant moments in world history was a far more complex undertaking. It involved the cooperation of NASA stations in Australia and the United States, Australia's international telecommunications agency OTC, Australia's domestic communications agency, PMG, and the CSIRO Parkes Radio Telescope. Overcoming the technical challenges involved in receiving television from the Moon and broadcasting it to the world, earned the Australian entities involved a unique tribute: in 1969, they received a special "Penguin Award" from the Television Society of Australia for technical achievement for the Apollo 11 broadcast.

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