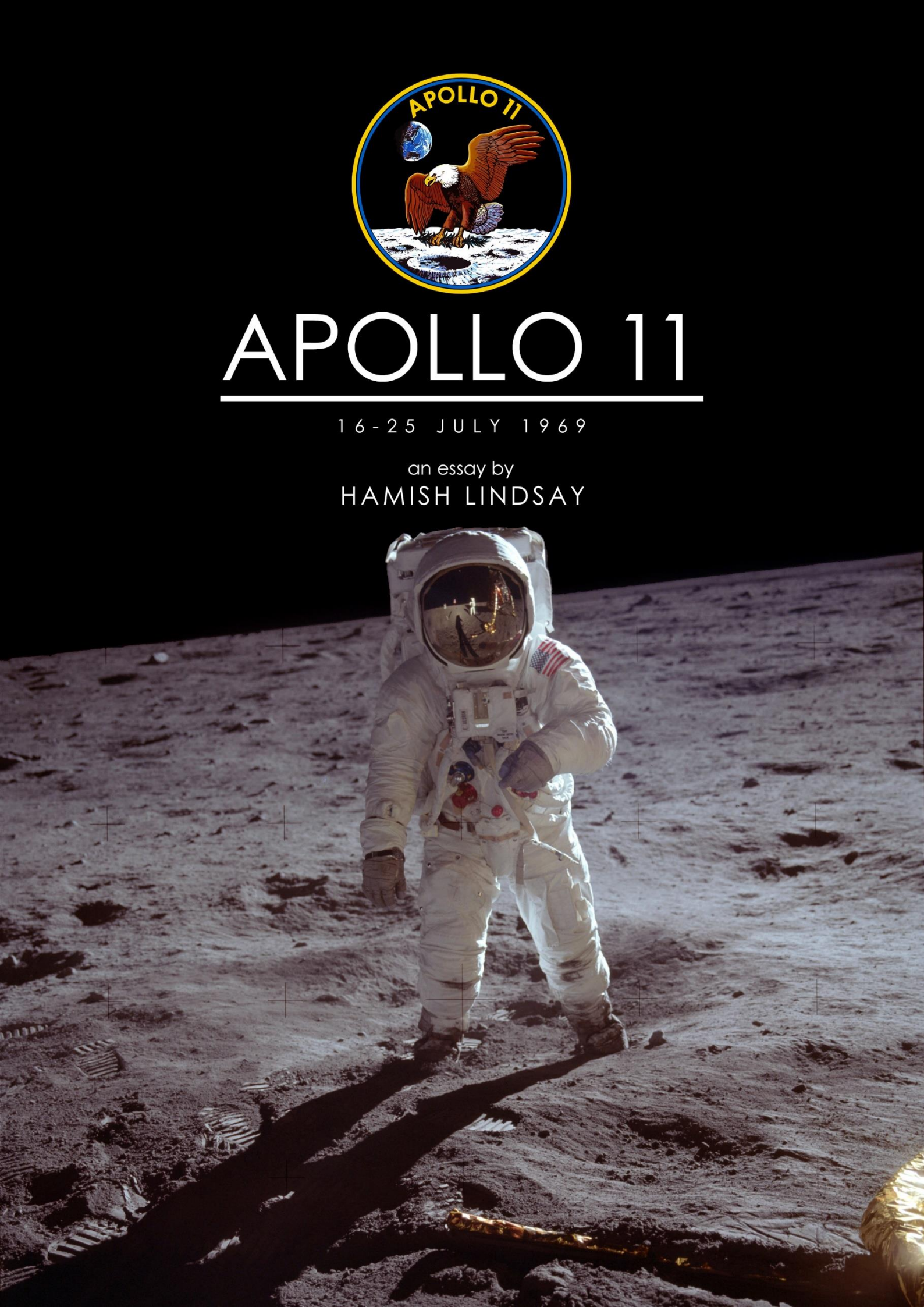


APOLLO 11

16-25 JULY 1969

an essay by

HAMISH LINDSAY

“The Lunar landing of the astronauts is more than a step in history; it is a step in evolution.”

The New York Times Editorial, July 20, 1969

APOLLO 11

16-25 JULY 1969

an essay by

HAMISH LINDSAY

extracted from content on the
Honeysuckle Creek Tracking Station
website, developed by Colin Mackellar

THE APOLLO 11 CREW

Neil Armstrong, Michael Collins, Edwin Buzz Aldrin

AS-506/CSM-107/LM-5 G MISSION CG 725

PRIME CREW

Commander: Neil Armstrong

Command Module Pilot: Michael Collins

Lunar Module Pilot: Edwin Buzz Aldrin

BACK-UP CREW

Commander: James Lovell

CM Pilot: William Anders

LM Pilot: Fred Haise

SPACECRAFT

Command Module: **COLUMBIA** CSM-107

Lunar Module: **EAGLE** LM-5

Notes

This description of the Apollo 11 Mission, based on the story in my book "Tracking Apollo to the Moon," is centred on a Honeysuckle Creek local timeline (Australian Eastern Standard Time), not the usual US Central (Spacecraft) Time. Ground Elapsed Time (GET), i.e., from 00:00:00 at launch, is included for a quick reference where events occurred in the mission, and to relate it directly to the Apollo Lunar Surface Journal and The Apollo Flight Journal.

To identify Space/Ground dialogue the text is shown in *italics*.

A list of official acronyms used in the text is at the end of the essay.

Mission Fact Box

Launch from Pad 39A, Cape Kennedy
0932:00 USEDT / 1332 :00 UT / 2332:00 AEST
Wednesday 16 July 1969

Earth to Moon elapsed time
73 hours 5 minutes 35 seconds

Lunar landing
GET 102:45:40
2017:39 UT Sunday 20 July 1969
0617:39 AEST Monday 21 July 1969

Lunar landing coordinates
Mare Tranquillitatis
0.67409°N, 23.47298°E (Davies et al 1987)

Commander on lunar surface
GET 109:24:15 / 0256:15 UT
2256:15 USEDT Sunday 20 July 1969
1256:15 AEST Monday 21 July 1969

Total lunar stay time
21 hours 36 minutes 21 seconds

CM lunar orbits
30 orbits
2 days 11 hours 30 minutes 26 seconds

Time on the lunar surface
1 EVA totalling
2 hours 31 minutes 40 seconds

Total distance walked
1,006 metres

Max. distance travelled away from the LM
61 metres

Lunar samples 21.55 kilograms
Lunar photographs 339 images

Lunar lift-off
GET 124:22:01
1754:00 UT Monday 21 July 1969
0354:00 AEST Tuesday 22 July 1969

Moon to Earth elapsed time
59 hours 36 minutes 52 seconds

Splashdown
GET 195:18:35
1650:35 UT Thursday 24 July 1969
0250:35 AEST Friday 25 July 1969

Total mission elapsed time
8 days 3 hours 18 minutes 35 seconds

Total distance travelled in space
1,534,832 kilometres

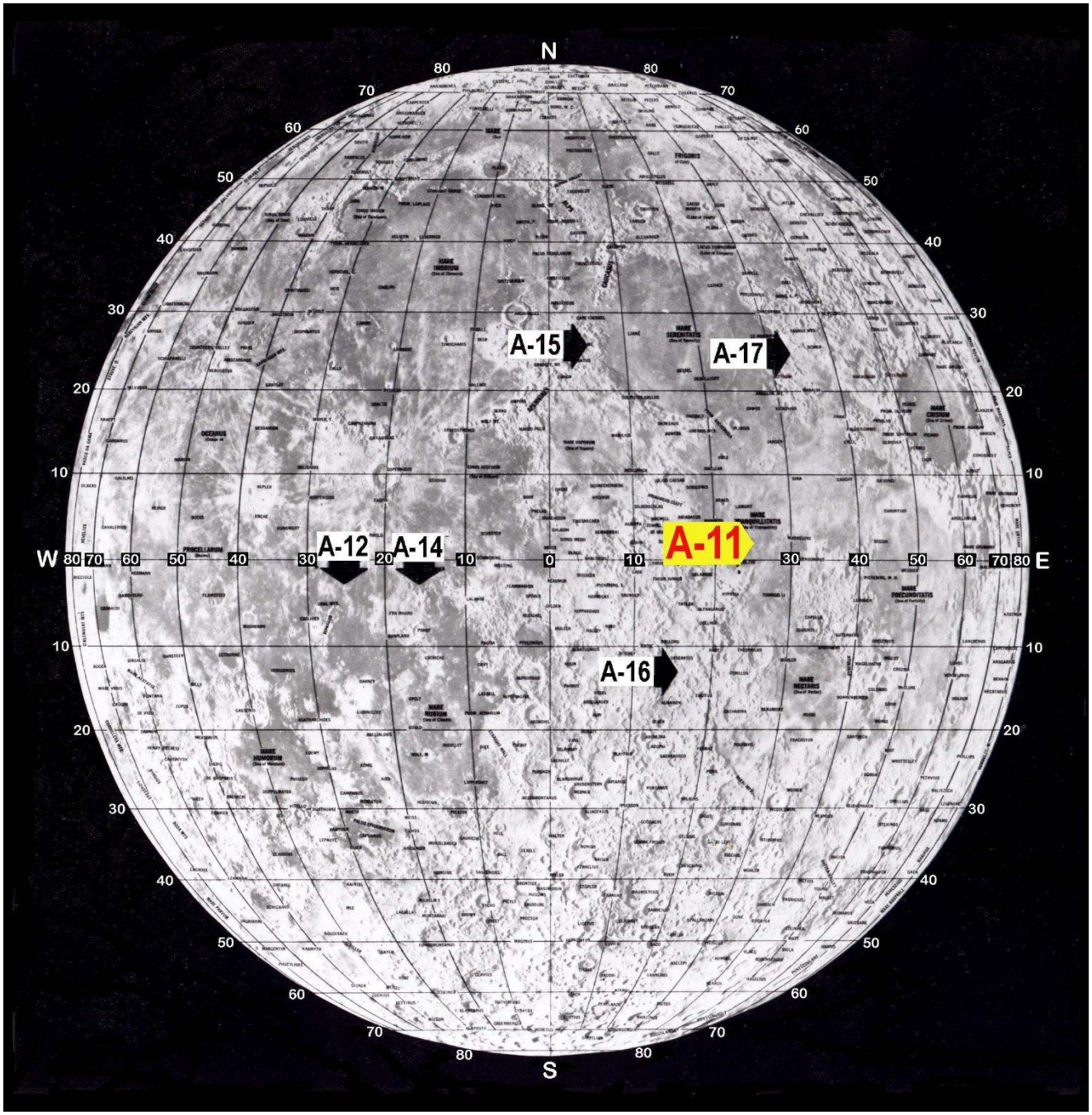
Site selection

Why Tranquillity Base?

Science and the scientists took a back seat in choosing the first lunar landing site, as it was seen more as an operational and engineering exercise to trial all the new procedures and systems. So, the operational and engineering aspects mainly dictated where the first landing would be.

Thirty possible sites for the first lunar landing were originally under review by the Site Selection Board. After two years of intense analysis, which included Lunar Orbiter images and Surveyor Lander data, the choice was narrowed down to two candidates – Mare Fecunditatis or Mare Tranquillitatis.

Launch opportunities (or windows) for the chosen site and time only occurred once a month, with two windows per day. One window was a Translunar Injection over the Pacific Ocean, which used a daytime launch, and the other was over the Atlantic, which meant a nighttime launch (as in Apollo 17). So, the first requirement by the Flight Dynamics team was for the site to be east of the lunar meridian to cater for back-up sites with suitable lighting in case the launch had to be delayed for some days. It seemed better to try a second site a few days later than wait for a whole



The Apollo 11 landing site, illustration modified by Hamish Lindsay

month for the prime site to present an opportunity again. Also, an easterly target was preferred because the LM would fly in from the east to land shortly after sunrise, when surface objects cast revealing shadows.

Secondly, they wanted the site to be within 5° of the lunar equator. A higher latitude site would consume more fuel, and fuel economy was one of the prime considerations for the first attempt.

A third requirement was the spacecraft was sent on a 'free return' translunar trajectory, so it would return to Earth without using major manoeuvres.

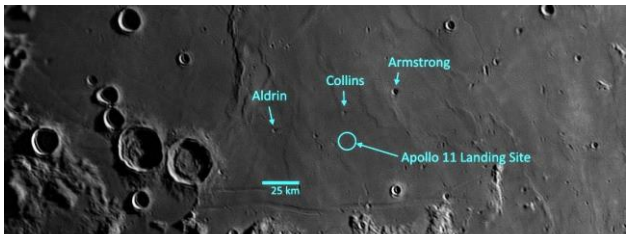
Finally, they wanted a flat area free from sharp ridges, large boulders or awkward steep sided craters for a first attempt.

These constraints narrowed the first attempt to land on a maria near the equator, which meant either Mare Fecunditatis or Mare Tranquillitatis, with Sinus Medii as a possible back up.

As Mare Fecunditatis would have provided difficulties tracking from Earth, a higher fuel consumption and the possibility of a night splashdown, it dropped out of favour.

So, the choice settled on Mare Tranquillitatis, originally named by astronomers Francesco Grimaldi and Giovanni Riccioli of Bologna in 1651. Here there were two possible landing targets in the area, an easterly one near Maskelyne Crater called ALS (Apollo Landing Site)-1 and ALS-2, a bit further west. ALS-2 was only 25 kilometres southeast from Surveyor 5's home, and Apollo 10 had made a low pass over the spot with favourable reports from Tom Stafford. ALS-2 also allowed a two-day recycle in the case of a delay to the next site Sinus Medii.

Though science did not play a major factor in the choice of the first landing site, the choice of ALS-2 made the scientists happy enough too. They felt that ALS-1 was too exotic, and for a first mission they wanted a more typical mare like ALS-2 with large, subdued craters and few boulders.



Crew choice

With a number of options for the crew, and it being such a monumental mission, the Director of Flight Crew Operations, or 'Chief Astronaut' Deke Slayton, decided to stick to the normal routine of rotating the backup crews, which put Neil Armstrong, Buzz Aldrin, and Fred Haise on the Apollo 11 mission – but there was an unexpected development. Michael Collins was back on flight status after surgery for a bone spur in his neck. He was anxious for a berth, which reminded Slayton he had originally promised him a lunar landing flight. As Haise hadn't figured in the original plans, Collins replaced him as Command Module pilot.

On 23 December 1968, while Apollo 8 was circling the Moon, Slayton approached Armstrong and asked if he would be happy with Collins and Aldrin as his crew for Apollo 11. If Armstrong had any doubts about Aldrin, Slayton offered Jim Lovell instead. Armstrong took a day to make his mind up, and decided he would stick with Aldrin, as, "I thought he (Lovell) deserved his own command. I thought it would not be right of me to pull Lovell out of line for a command – so he ended up with Apollo 13." Armstrong also had had no problems working with Aldrin in their role as back-up crew for Apollo 8. Another aspect that troubled Armstrong was – if Lovell came on board, it would best be as CM Pilot, as he was on Apollo 8. But Collins was also a CM pilot specialist.

So, Lovell wasn't considered any more, and Aldrin joined the Apollo 11 crew. He fitted in quite well, as he had already trained on the Lunar Module before the Apollo 8-9 crew swap, so he moved across to become the Lunar Module pilot. Thus, the Apollo 11 prime crew became Neil Armstrong, Commander, Michael Collins, Command Module (CM) pilot, and Buzz Aldrin the Lunar Module (LM) pilot. Collins and Aldrin were told on 4 January 1969 and on 9 January 1969 the media and public were informed, following ceremonies awarding the Apollo 8 astronauts their medals.

It should be noted that at this point the LM had yet to fly. Armstrong commented, "A lot of things we just didn't know at that point, and I think I did not really expect that we'd get the chance to try a lunar landing on that flight. Too many things could go wrong on Apollo's 8, or 9 or 10."

Neil Armstrong, Commander
NASA Photo S69-31741

CDR

Neil Armstrong

Neil Alden Armstrong, aged 38 for the mission, was born in Wapakoneta, Ohio, on 5 August 1930.

He received a BSc in Aeronautical Engineering from Purdue University and a Master of Science in Aerospace Engineering from the University of Southern California. He was a naval aviator from 1949 to 1952, flying 78 combat missions in the Korean War. He was an engineer, test pilot, astronaut and administrator for NACA and its successor, NASA, for 17 years. Armstrong flew more than 200 different types of aircraft, from jets, rockets, helicopters and gliders to the glamorous X-1 and X-15 rocket planes. In 1962, he became an astronaut and first entered space in Gemini VIII, commanding his spacecraft to the first ever docking of two vehicles in space, before the mission was aborted off China. He was a Professor of Aerospace Engineering at the University of Cincinnati for eight years.

Armstrong was decorated by 17 countries and his awards include:

The Presidential Medal of Freedom, the Congressional Gold Medal, the Congressional Space Medal of Honor, the Explorers Club Medal, the Robert H. Goddard Memorial Trophy, the NASA Distinguished Service Medal, the Harmon International Aviation Trophy, the Royal Geographic Society's Gold Medal, the Federation Aeronautique Internationale's Gold Space Medal, the American Astronautical Society Flight Achievement Award, the Robert J. Collier Trophy, the American Institute of Aeronautics and Astronautics (AIAA) Astronautics Award, the Octave Chanute Award and the John J. Montgomery Award.

He left NASA in 1971, after spending 206 hours 12 minutes in space, and died on 25 August 2012.

Mike Collins, Command Module Pilot
NASA Photo S69-31742

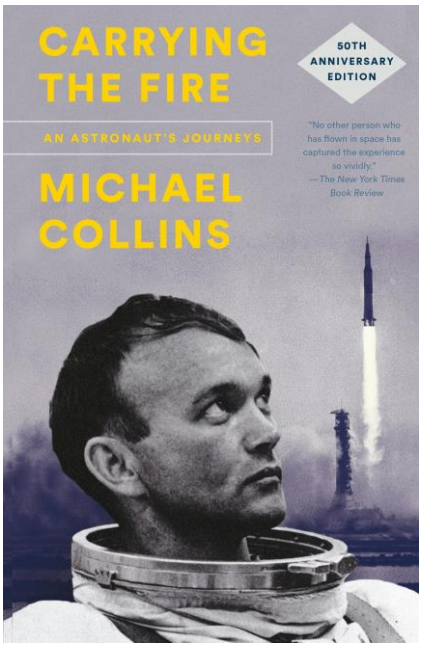
C M P

Collins wrote one of the best astronaut books, Carrying the Fire. He left NASA in January 1970 after 266 hours 4 minutes in space, to become the Assistant Secretary of State for Public Affairs before he was appointed the Director of the National Air & Space Museum, Smithsonian Institution, Washington.

Mike Collins

Michael Collins, aged 38, was born on 31 October 1930 in Rome, Italy.

In 1952 he received his BSc from the United States Military Academy at West Point, New York. Collins joined NASA in October 1963 and was the back-up pilot for the Gemini VII flight before entering space as pilot in the Gemini X mission with John Young. In 1968 he was diagnosed with cervical disc herniation requiring two vertebrae to be fused together, which took him off flight status for three months. He was presented with the Presidential Medal of Freedom in 1969, the NASA Exceptional Service Medal and the Air Force Distinguished Flying Cross.



Edwin 'Buzz' Adrin, Lunar Module Pilot
NASA Photo S69-31743

L M P

His honours include the Presidential Medal for Freedom in 1969, the Robert J. Collier Trophy, the Robert H. Goddard trophy and the Harmon International Trophy.

He resigned from NASA in July 1971 after logging 289 hours 53 minutes in space.

Edwin Aldrin

Dr. Edwin Eugene "Buzz" Aldrin, Jr. aged 39 was born on 20 January 1930 in Montclair, New Jersey.

In 1951 he gained his BSc in mechanical engineering from the United States Military Academy at West Point, New York, graduating third in his class. With a thesis on "Guidance for Manned Orbital Rendezvous" he was presented with his doctorate of Science in Astronautics from the Massachusetts Institute of Technology, Cambridge. He flew 66 combat missions in Korea, shooting down two MIG aircraft.

Aldrin joined NASA in October 1963 and entered space as James Lovell's pilot in Gemini XII, creating a new record of 5 and half hours walking in space.

Armstrong, Aldrin, and Collins had watched Apollo 10 very closely, and were very relieved when it was declared a success, as it meant that their Apollo 11 mission would be the first attempt to land. Compared with Alan Shepard's 150 hours of simulations for his first Mercury flight, they had each spent over 1,200 hours, a total of 3,521 actual training hours, working 14-hour days, 6 days a week for a full 6 months, in simulators wrestling with a continuous stream of missions, usually peppered with emergencies, equipment malfunctions, and potential catastrophes to test their knowledge, skill, and coolness to the limits. On the science side, Jack Schmitt (Apollo 17 LM Pilot) spent a lot of time preparing them for lunar rock collecting. By the time they were ready for going to the moon, the astronauts knew every twist and turn of the normal and emergency

The Mission patch featured an Eagle bearing an olive branch.

operational procedures as well as every capricious component of the spacecraft's 26 subsystems.

Choice of names for the spacecraft

According to Armstrong many, many people suggested the names of the spacecraft. The crew chose the two, Columbia and Eagle, as representative of the flight and the nation's hope. Columbia stands on top of the Capitol in Washington and was the name of Jules Verne's spacecraft that went to the Moon. Armstrong commented that Collins was especially thoughtful about the name.

Aldrin and Armstrong chose Eagle for the Lunar Module from another long list of suggestions.

Who steps onto the Moon's surface first?

The question of who stepped out on the Moon first began a heated debate among certain people. A reporter raised the subject during the very first press conference on 9 January 1969, and the answer was it had not been decided, but the simulations would settle that point at a later date.

Aldrin had never given it much thought, always believing he would be the first out, as in Gemini the pilot always leapt out to do the EVAs. The early flight plans and timelines had the LM Pilot out first. Newspaper headlines of the time reinforced this thinking, and members of NASA Headquarters agreed. But after Apollo 9's successful flight and it looked like Apollo 11 was really going to attempt the landing, the subject of who stepped out first began to take on a new significance.

Aldrin began to hear rumours about Armstrong being the first to step out, "because he was a civilian."

This angered Aldrin as he felt it was a slight to the military, and began to question everyone, including Armstrong, bringing up various technical reasons why he should be first out. Instead of understanding, he met with a lot of resistance from his colleagues, who could not understand his frantic lobbying to be first out.

Slayton explained to Aldrin that Armstrong was senior to him, having joined the astronaut core in the group ahead, and as Commander it was only right that Armstrong should step on the Moon first. In the end NASA explained that the first out was based solely on the LM's interior design and the physical locations of the two astronauts inside the cabin. Aldrin, as pilot, would be on the right side and Armstrong would be on the left, next to the hatch opening. So, it would not be practical to change positions with Armstrong to access the hatch opening, considering the lack of room and the chance of damaging equipment and instrument panels with their bulky backpacks.

EVA training

Neil Armstrong (left) and Buzz Aldrin during a simulation of the EVA in Building 9 at the MSC in Houston. Image AS11-S69-31123. Courtesy of the Apollo Image Gallery.

So, it was decided that Armstrong would climb out first, Slayton announcing, "Just on a pure protocol basis I figured the Commander ought to be the first guy out."

Did Armstrong pull any strings as alleged by some media?

"Absolutely not," said Slayton.

Neil Armstrong (left) and Buzz Aldrin during a simulation of the EVA in Building 9 at the MSC in Houston. Image AS11-S69-31123. Courtesy of the Apollo Image Gallery.

"I was never asked my opinion," said Armstrong.

"It was fine with me if it was to be Neil," Aldrin agreed at the time. But Collins noted, "Buzz's attitude took a noticeable turn in the direction of gloom and introspection shortly thereafter."

Armstrong had always insisted it was not an important issue to him, it was more important to him that, "… they got four aluminium legs safely down on the surface of the Moon while we were still inside the craft."

However, the final comment on this subject should come from Director of Flight Operations, Chris Kraft. He told me in an interview, and subsequently wrote in his autobiography Flight: My Life in Mission Control, that there was a meeting in March 1969 between Deke Slayton, Director of Flight Crew Operations, Bob Gilruth, the Director of the Manned Spacecraft Center, George Low, the Apollo Program Manager and Kraft. They unanimously agreed that they wanted Armstrong, not Aldrin, to be the immortal historical figure, as he was the example of the great American hero – calm, quiet, softly spoken with absolute confidence and with no ego. They issued an order that Armstrong must be the first on the Moon's surface.

So, Neil Armstrong became the hero whose name will reverberate throughout human history for the rest of time.

Getting the television pictures From Honeysuckle Creek to the outside world

At this point there was no provision to transmit a television picture direct from Honeysuckle Creek to the outside world, and it was decided to install a television link from Honeysuckle Creek to Canberra. Trevor Gray was a PMG (now Telstra) technician on the installation team,

"We worked hard night and day to get this link in place. First a temporary tower was put up beside the road into Honeysuckle, and dish antennas mounted on top. Equipment was then connected to them, most of it in the basement of the station building. The link went from Honeysuckle to Williamsdale, then back to Red Hill in Canberra

(The Telstra Tower on Black Mountain did not exist back then).

The temporary tower at Honeysuckle to relay the TV is seen at right.
Photo: Hamish Lindsay. More details here. Unlabelled photo here.

We had mixed-up brand dish antennas everything was grabbed from everywhere. We were told there was no money for capital works we couldn't buy anything, but there was plenty of money for operations. There was some Collins gear that NASA had, and we had to match their gear to our gear, so someone showed us a lathe out the back of Honeysuckle and having had a few hours of experience on lathes before we made these joints up and bolted them together. For the actual moon landing the ABC (Australian Broadcasting Corporation) put in another link in beside ours, so we had two links plus a standby.

These links were difficult to maintain. It was wintertime and very cold. There was a high voltage in these joints and moisture got in them, and a few of them blew up – naturally, some in the middle of the night. We ended up sealing them with epoxy resin. Normally these links were designed to be up for only an hour or so, say during a football match. They weren't meant to stay there for long. By the time of the first moon landing, we had it settled down enough to last through the mission. It meant that not many of us got much sleep."

Mike Dinn remembers: "Two dishes were for Parkes (via Sydney) incoming – prime and backup. The other pair for outgoing TV, prime and backup."
Screenshot from ABC footage taken on the morning of the Moonwalk. Used with permission.

Choice of launch time

Dr. Kurt Debus, Director of the Kennedy Space Center and once a war-time V-2 launch director in Germany, finally announced, “When the weight of the paperwork equals the weight of the Stack it’s time to launch.” The Saturn V vehicle was commonly called “the stack.”

Actually, the time to launch Apollo 11 was carefully chosen so that the Lunar Module would land on the Sea of Tranquillity with the morning sun low enough to throw strong shadows on the lunar surface for the best feature manifestation from above. The mission planners set 16° as the highest sun angle for a landing and 6° the lowest and judged that anything greater than 20° was unsatisfactory for a manual landing. Also, Apollo 11, as with the other lunar missions, was sent to orbit around the moon in a clockwise direction so that the sun would be behind the Lunar Module, and not in the astronauts’ eyes as they came into land.

A lunar day lasts two Earth weeks, so it takes seven days for a morning to reach a lunar midday when the temperature soars to 110°C. During the two-week lunar night, the temperature plummets to minus 170°C.

Armstrong explained the choice of landing time:

“The primary reason was that we wanted to land early in the morning that is when the sun was at a fairly low angle, between 5 and 15 degrees above the horizon, so the temperatures wouldn’t get to us and also so the lighting would be good in that we would have quite a lot of shadows in the landing area so our depth perception would be as good as possible.

The Moon has a very peculiar lighting characteristic. If you walk out in your backyard and look at the Moon, it doesn’t have a bright spot on it. If you look at a Christmas tree ball, it has a shiny spot where you have a direct reflection of a light source, and this is called specular lighting. But if you look at the moon from your backyard it is almost equally illuminated all over. This characteristic is further represented by the fact that light comes right directly back into your face from the sun. All of you who have flown close to clouds or low to the ground over dewy fields know that when you look at your shadow it has a bright halo around it. That particular characteristic is very much larger on the moon. You have a very bright spot right along the sun line shining back into your eyes. It’s so bright that we were considerably worried about it, and we wanted to choose the final descent so that we wouldn’t be looking into this bright spot of light right down our flight path. So, these various considerations boxed us into a fairly tight approach angle, and we wanted to be fairly close to where the shadow was so that the sun would be only about 10 degrees above the horizon.”

Prelaunch activity

The night before the launch, lights burned late in Cape Canaveral, in Houston, and around the world as the operational, technical, recovery and rescue teams prepared their equipment and the vast, complex, communication networks supporting the flight.

The worldwide Manned Space Flight Network consisted of 17 stations, 4 ships and 8 aircraft.

On the other side of the world from Cape Canaveral, at Honeysuckle Creek, Deputy Director Mike Dinn reflected on his role:

“The chances of hardware problems in the spacecraft and on the ground which could seriously jeopardise the mission’s success were much less than the chances of a person pushing the wrong button at the wrong time. For example, unless the antenna is pointed at the right place at the right time the station might as well not be there.

Also, when the antenna technician has done his part, the transmitter and receiver technician must push the right buttons at the right times if any data or voice up or down to the spacecraft is to be received. This operational performance requirement follows down the line, i.e. the chain is as strong as its weakest link.

My role in this mission, as Operations Supervisor, is to coordinate station planning and operations to make each link of the chain as strong as possible, and to efficiently use parallel chains wherever available, so that a possible failure in a link would be covered. Being involved in the detail of the station it is very easy to lose sight of the overall picture somewhat analogous to a stage manager who must be aware of all details of the production, but never sees the end product as does the audience.

I see this mission as being only a further step in man's inevitable curiosity and drive to explore and look forward to taking a part in future steps of this kind."

With an event such as the Apollo missions, a lot of our daily preoccupations are no longer applicable to travellers in space. Once they have left the Earth the weather, for instance, is of no interest to the astronauts as they have no weather, and they can select any of Earth's time zones for their day, as they have no sunset or sunrise.

Mission Control prepares

The Mission Operations Control Room (MOCR) consisted of a tight group of exceedingly bright young specialists with an average age of 26 years working as a team under the Flight Director. They could solve almost any problem or come up with an alternative in their field under pressure, usually working in seconds. In twenty seconds, a controller could spot and evaluate a problem, discuss it with his support team and inform the Flight Director of his decision of any action to be taken, all the while monitoring events going on around him. Like the astronauts, these teams had spent countless hours suffering tough simulations to be prepared for any emergency.

The Director of Flight Operations, Chris Kraft, organised four Mission Control flight control teams for Apollo 11 – run by:

- Clifford Charlesworth (Green Team)
- Glynn Lunney (Black Team)
- Gene Kranz (White Team) and
- Milton Windler (Maroon Team).

Kraft himself had already retired to the back row to keep his steely eye on events. He visited the three astronauts in their pre-flight germ-isolated accommodation and checked out last minute details.

Then Kraft, aware this was the most ready space mission ever, asked, "What can we do? Is there anything we've missed?"

Armstrong answered, "No, Chris. We're ready. It's all been done except the countdown."

Kraft looked at the three men and realised that this was the moment they had all been working towards – they were about to land on the Moon, "Our work, our dreams, our failures, and our successes all rode with them. We had come at last to this point, and for a moment I felt my legs shake."

Armstrong speaks of the flight

Commander Neil Armstrong said of the mission:

"We had a great deal of confidence. We had confidence in our hardware; the Saturn rocket, the Command and Lunar Modules. All flight segments had been flown on the earlier Apollo flights with the exception of the descent and ascent from the moon's surface, and of course, the exploration work on the surface. As we ascended the elevator to the top of the Saturn, we knew hundreds of thousands of Americans had given their best effort for us.

Now it was time for us to give our best."

LAUNCH

Wednesday 16 July 1969
Launch time: 00:00:00 GET
0932:00 USEDT, 1332:00 UT 2332:00 AEST

The weather on launch day turned out to be cloudy with lazy southerly breezes up to 6 knots from the south. Cumulus clouds from a base of 2,400 feet covered 10% of the sky with altocumulus over 20%. High above, cirrostratus spread over 90%. The temperature had drifted up to 29.4°C and humidity 73%. The rumble of distant thunderstorms could just be heard.

The three astronauts began the day at 0415 USEDT with a breakfast of orange juice, steak, scrambled eggs, toast and coffee. They emerged from breakfast still holding their toast and found their friend Joe Schmitt and his team of four technicians preparing their space suits.

Schmitt, "We suit technicians had been working in the suit room since 3:30 am, turning on the air and oxygen supply, making leak checks on the suit consoles, checking out the communications systems, laying out suit equipment, making sure suit pockets were loaded in correct order with pens, flashlights and so forth.

On Neil's suit a small folding shovel with plastic sample bags were placed in the special pocket.

The Apollo 11 crew with Bill Anders (far left) and Deke Slayton (right) at the launch day breakfast.
NASA photo KSC-69PC-368

These were to be used in the event that their stay on the Moon was to be cut short for any reason, so at least they would come back with a few lunar soil samples. Suiting begins with crewmen slipping into their long-john underwear up to their waists at which time the biomed technicians placed the biomed censors on the chest and a preliminary EKG test check is made.

After buttoning up the upper part of the underwear, the athletic supporter and urine collection device was donned. I might point out that two sets of underwear were used. The cotton long-johns were used for the launch and landings, while the liquid cool underwear was stored until needed for the moon landing. Also, two types of space suits were used. Mike Collins wore an intravehicular suit, which means that these suits were only to be used inside the spacecraft, while Neil and Buzz wore extravehicular space suits. Three extravehicular [suits] were purchased for each crewman – one for training, one for flight and one back-up flight suit.

A ham on rye sandwich was carried along as a quick snack. With the countdown going rather smoothly, we proceeded with the final phases of suiting. Communication carriers were donned, and a communications check was made. Nylon comfort gloves followed by the suit gloves were donned and locked to the suit arms. Next the fishbowl helmets were locked into the suit neck rings. At this point, the pre-breathing begins, as we turn off the air and turn on the breathing oxygen supply. Pressurised suit leakage checks are made after which the crew would lounge comfortably in their reclining chairs until we got the go ahead from the pad leader, Guenter Wendt, to proceed to the spacecraft."

Armstrong suits up on launch day.
NASA image KSC-69PC-377, via the Apollo Image Gallery.

Suiting up

The suits were pumped up to a pressure of 131 kPa of pure oxygen and for three hours the astronauts had to purge their bloodstreams of nitrogen. Then they walked out and climbed into the waiting Transfer Van, its flashing lights shooting red beams into the pale early morning light during the 20-minute drive. Unable to hear the small crowd of people gathered to see them off, the three astronauts just grinned and waved back.

The crew enter the Transfer Van.
NASA image KSC-69PC-412

Meanwhile, up in the Command Module the back-up Lunar Module pilot, Fred Haise, was working with Guenter Wendt, the Pad Leader and five other technicians, steadily and systematically going over the spacecraft, checking the 678 switches and circuit breakers were in the right position. As his eyes and fingers flicked over the panels, he could hear the familiar noises of the water glycol cooling system and cabin and suit fans whirring away around him.

The crew board their spaceship

The three astronauts with their technicians climbed out of the transfer van to take the first elevator up to the base of the Saturn V rocket. Walking through a sealed compartment they saw that Guenter Wendt had placed signs along the walls which read “The Key,” followed by another one, “To the Moon,” then another, “Located In,” and finally, “The White Room.” A few more steps and they came to the base of the high-rise elevator, which took them to the 97.5 metre level where the spacecraft hatch was located.

Deke Slayton, the Director of Flight Crew Operations, had ridden out to the pad in the van and farewelled them with, “Watch your asses and have a good trip,” as they entered the elevator. At the top on the crosswalk as Armstrong walked towards the white room door he paused to look down, giving Slayton a final wave.

Arriving at the White Room door, they were greeted by Guenter Wendt holding a huge key, which he presented to Neil Armstrong, who in turn gave Guenter a card reading, “Space Taxi ticket, good between any two planets.”

Neil Armstrong appears deep in thought, as he and Mike Collins walk towards swing arm nine and the White Room.
Scan courtesy Kipp Teague

In the White Room at the top of the Stack the Apollo crew at the hatch of the Command Module. July 3rd, 1969, during the Countdown Demonstration Test.

Michael Collins looking down on the back left, Neil Armstrong with Guenter Wendt, the Pad Leader, behind him. In the left foreground Buzz Aldrin in earnest discussion with a pad technician.
Scan courtesy Ed Hengeveld

At 0654 local time, while Armstrong slipped out of his yellow boot protectors and swung himself through the hatch to settle down in the left couch, Collins paused on a narrow walkway from the elevator to savour the view and to consider the moment before climbing into the right couch.

Buzz Aldrin recalled:

"While Mike and Neil were going through the complicated business of being strapped in and connected to the spacecraft's life support systems, I waited near the elevator on the floor below. I waited alone for fifteen minutes in a sort of limbo. As far as I could see there were people and cars lining the beaches and highways. The surf was just beginning to rise out of an azure, blue ocean. I could see the massiveness of the Saturn V rocket below and the magnificent precision of the Apollo capsule above. I savoured the wait and marked the minutes in my mind as something I would always want to remember."

Aldrin eased himself into the centre couch and waited for Joe Schmitt to couple him into the spacecraft systems, "My recollection," he said "was a mass of hands reaching and tugging from several directions. Mike, Neil and I were fairly helpless at this time – three totally battened down people waiting for the ride to start."

Schmitt, "My workstation for ingress was just inside the spacecraft hatch just above the centre seat, which means I had to get out each time the next crewman got in. I had to do a lot of stretching to reach the oxygen valves located in the tunnel of the spacecraft."

With all three astronauts comfortable in their carefully contoured couches, the last task for Joe Schmitt before he left was to check the oxygen to the suits, leaving Fred Haise to the final checks – straps, loose gear, and a look around for anything abnormal. He was unable to speak directly to the astronauts, but could hear them through the intercom:

"They were locked in their suits," he told me, "And I went down in the capsule and assisted the two suit technicians to transfer from the portable oxygen to the spacecraft supply and strap them in. We all shook hands and as I crawled out I tapped Buzz on the shoulder. From the point of view of wishing them well this was the first attempt, so frankly at that time we didn't know they were going to land. All the missions have their chances for failure, as I found out later in Apollo 13. We then exited and went through the hatch closure sequence and checked the leak test. Then we departed the pad to about the half-way point, about an hour and a half before launch."

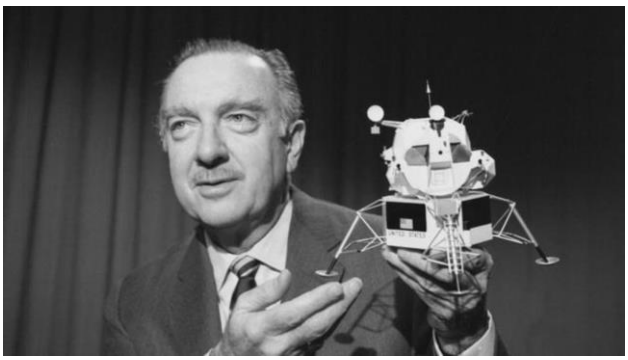
Unable to get up and look back and see the sunny world through the windows outside, the three astronauts settled down to wait for ignition, isolated from the Earth except for their intercoms. Everything was GO for launch.

It was 7:52 am local time.

Walter Cronkite defines the moment of Apollo 11 before lift-off

The legendary American television commentator Walter Cronkite described his feelings of the moment:

"It was so much different from any other flight – it was something that had to grip you. You knew darned good and well that this was real history in the making. The thing that made this one particularly gripping was that sense of history, that if this was successful this was a date that was going to be in all the history books for time evermore – everything else that happened in our time is going to be an asterisk. I think we sensed that at the time – that this was it."



Suspense builds as launch time approaches

At the launch control centre in Firing Room One, 463 technicians and engineers, backed by 5,000 specialists on standby, hunched over their consoles, intently studying their flickering screens, watching countless checks and tests of the whole Saturn V rocket being performed. When their task was completed successfully, they announced, "GO" on the intercom.

Finally, all the checks were completed – the great rocket was ready. "Good luck and God speed from the launch crew," called Paul Donnelly, the Launch Operations Manager, to the astronauts over the intercom.

Audio

Hear the Network Controller's loop at Mission Control starting at t-20:00. (Link to page.)

Hear the Network Controller and Flight Director loops starting at t-5:00.

- Bruce McCandless is Capcom
- Flight Director is Cliff Charlesworth
- Richard Stachurski is Network Controller.

At Honeysuckle Creek we were approaching midnight and finishing our SRT (Site Readiness Test) and preparing for Interface with the network when the final countdown started. We paused to listen and heard, "Twenty seconds and counting… fifteen seconds… guidance is internal… twelve… eleven… ten… nine…"

The estimated 750,000 people gathered to watch the launch were hung in suspense, listening to the count on their radios. At the official viewing site 5,000 invited guests from all over the world with 3,497 journalists in the press stand peered at the tall rocket shimmering in the morning haze.

All eyes were waiting for the first lick of flame at the base of the gleaming white rocket.

Nearby, fourteen men in flame protection gear in armoured personnel carriers tensed behind their bunker, ready to rush in to help the astronauts in an emergency.

The mighty Saturn V's engines fire

At T-8.9 seconds, Apollo 11's five F1 engines burst into life, spewing fire and smoke down the huge flame deflector below. 127,300 litres of cold water per minute flooded out over the walls, mixed with the searing flames to generate clouds of steam. An estimated 635 kilograms of ice formed on the rocket's skin from the super cold fuel within, flaked off in an avalanche of white. Thundering shock waves spread out, filling the sky with startled flocks of duck, heron, and small birds. Even in the bright daylight the glare from the flames became so intense it hurt the eyes.

Four giant clamps gripped the straining rocket as the engines built up to their full thrust. The launch team rapidly checked all systems were go.

Lift-off

T0 at 0932 USEDT (2332 AEST), "...all engine[s] running. Lift off. We have lift off."

With maximum thrust built up to the equivalent of 180 million horsepower, equal to 32 Jumbo jet aircraft at full throttle, the hold down clamps released the straining rocket. At first slowly, majestically, the mighty vehicle rose off the pad, sliding out of eight guiding taper pins for the first 15 centimetres. The rushing river of searing flames plastered the gantry and created flecks of fire dancing on the steel structure. As the vehicle set off on a flight azimuth of 72.058°, the fins at the base of the rocket cleared the tower and the flames and heat drew away to leave the blackened, blistered edifice standing empty… alone.

The Saturn V clears the tower, as seen from the LC-39 Press Stand.
NASA image 69-H-1134

Apollo 11 heads for space.
NASA image KSC-69PC-397

Audio

Hear the launch as described from the press stand by excited Australian Derryn Hinch.

Audio

Audio of the launch here.

77,200 litres of water per minute still tumbled down around the base to preserve it from being destroyed by the heat from the rocket blast.

"The tower is clear," announced Launch Control, and from that moment the mission became the responsibility of Mission Control in Houston, and us in the tracking network.

The three astronauts were not aware of the moment of lift-off, but first felt a powerful, insistent thrust to their backs accompanied by a distant rumble, rather like an express train. They were thrown left and right against their straps in spasmodic jerks as the big vehicle adjusted itself to wind effects, and to keep on the planned course. In the first forty seconds the 36-storey vehicle was travelling faster than the speed of sound, and the noise in the cabin dropped away. Armstrong noted that those first 40 seconds of flight were uncomfortably noisy and rough, much worse than the Gemini Titan launches. He found it was hard to hear any voices in his earphones, even with his helmet on.

The swampy coast of Florida rapidly receded as the Saturn V's motors guzzled 2,128 tonnes of fuel at a rate of 13.3 tonnes per second. In an incredible two and a half minutes the 3,198-tonne monster was travelling at 10,140 kilometres per hour, losing three quarters of its launch weight.

The huge crowd of onlookers stared through the heat haze at the shimmering image of the moon ship and saw two gigantic torches of flame shoot out of the bottom and splay out to billowing clouds of fire and smoke. They watched in awe as the rocket majestically rose into the sky and picked up speed to dwindle into a dot atop a spreading plume of smoke. Fifteen seconds later the very ground vibrated as they reeled from the shock waves, louder than any thunderstorm, passed by to dissipate behind them. Australian journalist Derryn Hinch said it was like being hit in the stomach with a cricket bat, and later he found bruises in his thighs from his shuddering desktop.

Into Earth orbit

As the three astronauts streaked through the thinning atmosphere, the blue sky in the windows darkened to the black of space.

At 3 minutes 18 seconds the launch escape tower jetted away, and Aldrin and Collins could now see out.

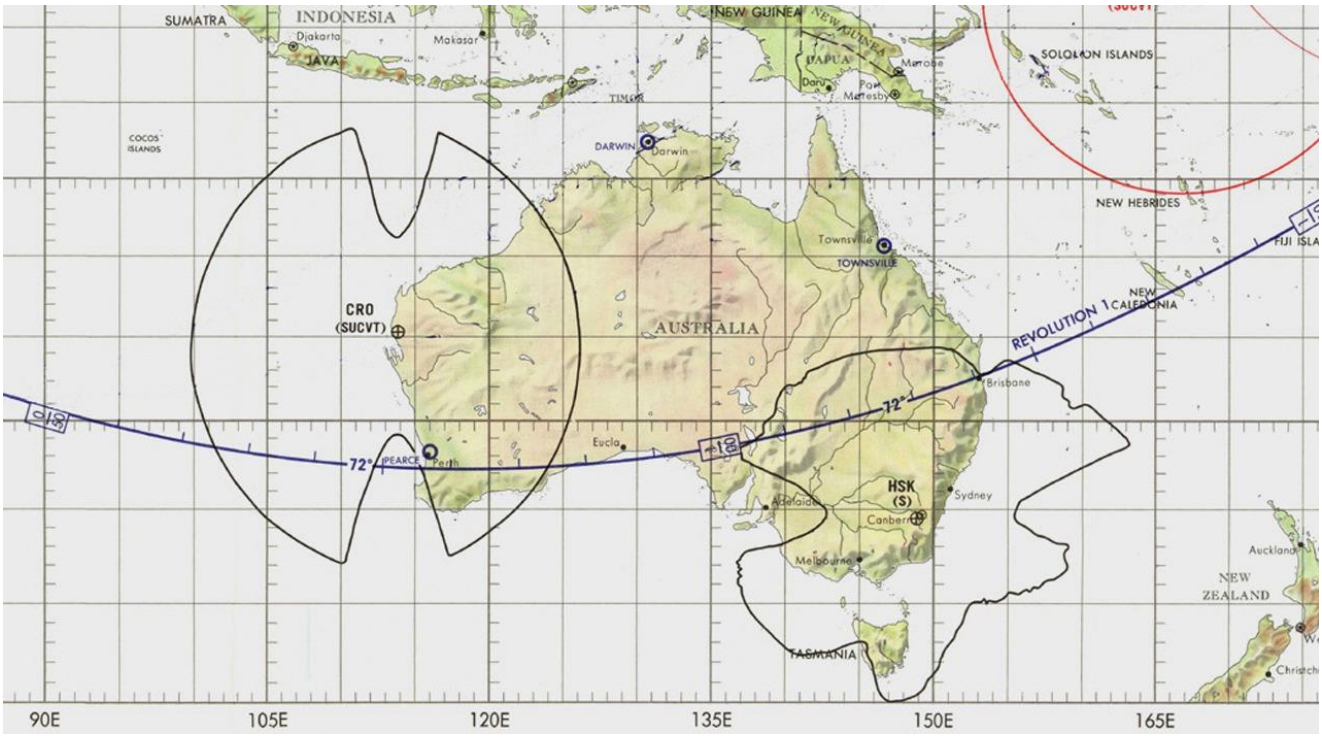
> Armstrong, *"Tower's gone."*
>
> McCandless, *"Roger, tower."*
>
> Collins, *"Yeah, they finally gave me a window to look out."*

At 11 minutes 49 seconds after launch, they entered into a 185.9 x 183.2 kilometre Earth orbit with a period of 88.2 minutes and a speed of 28,055 kilometres per hour. As they went over the Canary Islands they removed their helmet and gloves, and settled down to check that the spacecraft was ready for the big voyage.

At 28 minutes after launch, after passing Canary Islands Aldrin spoke up, "How are we doing on that time, anybody? Neil, are you sort of Master of Ceremonies on time, yet?"

> Armstrong began to reply, "Well, I didn't..."
>
> But Aldrin began singing and changed the subject, "Okay, your drinking water supply valve is ON."
>
> Collins, "Hey, Buzz."
>
> Aldrin, "Yes."
>
> Collins, "How would you like the camera?"
>
> Aldrin, "Okay."
>
> Collins, "Alright, Buzz, here's one Hasselblad for you."
>
> Armstrong, "Coming around the right-hand couch."
>
> Collins, "Buzz?"
>
> Aldrin, "Yes, just a second."
>
> Collins, "Okay, I'll just let go of it, Buzz. It will be hanging over here in the air. Coming up… it's occupying my couch."

So, the relaxed crew were playing with the still and movie cameras as they plunged into the night over Tananarive with Armstrong muttering, "Man, are we in the dark now!" On the Earth below 17 tracking stations, 4 ships, and 8 Boeing 707 ARIA (Apollo Range Instrumented Aircraft) jet aircraft followed every move by the spacecraft and reported back to Houston.



Apollo 11's ground track across Australia on their first orbit.
Coverage of Carnarvon and Honeysuckle Creek is depicted.
From the Apollo 11 Earth Orbit Chart. Scan: Hamish Lindsay.

After racing across the Indian Ocean towards Carnarvon in Western Australia, Paul Oats, Deputy Station Director at Carnarvon explained:

"We had three tracking systems operating. We locked up solid on the spacecraft before line of sight about 4,830 kilometres away over the Indian Ocean, and then tracked it over towards the eastern coast of Australia. The Americans were desperate to check out their programs and make sure everything was working properly."

Their powerful FPQ6 radar confirmed Apollo 11 was in the planned parking orbit.

Up in the spacecraft, with 52 minutes on their GET clock, they were preparing to meet Carnarvon in Western Australia with Collins announcing, "It says here, coming up on Carnarvon AOS at…"

McCandless, *"Apollo 11, this is Houston through Carnarvon, Over."*

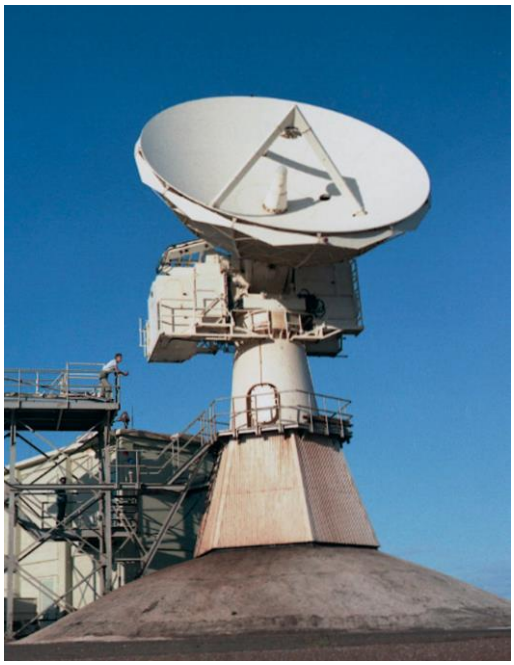
Aldrin, *"Houston, Apollo 11. Loud and clear, over."*

McCandless, *"Roger, we're reading you the same. Both booster and the spacecraft are looking good to us, over."*

McCandless, *"Apollo 11, this is Houston. One minute to LOS at Carnarvon. AOS at Honeysuckle 59:33. Over."*

Armstrong, *"Apollo 11. Roger."*

McCandless, *"And we request you turn up S-Band volume for the Honeysuckle pass."*



FPQ6 Radar at Carnarvon
Photo: Hamish Lindsay

The Honeysuckle Creek Operations console several weeks before Apollo 11.
Left to right: Operations Supervisors John Saxon (standing) and Ken Lee.
Station Director Tom Reid. Deputy Station Directors Mike Dinn (standing) and Ian Grant.
Larger version. Scan: Colin Mackellar.

HSK MISSION DAY 1

Thursday 17 July 1969

Earth Orbit 1

AOS: 0032:32 AEST

LOS: 0037:05

Track Duration: 4m 33s

Apollo 11 came up over our horizon right on time, 32 minutes after our midnight, for our first pass. The crew were busy getting ready for the pass over America with a bit of television through the Goldstone tracking station.

Part of the conversation through Honeysuckle:

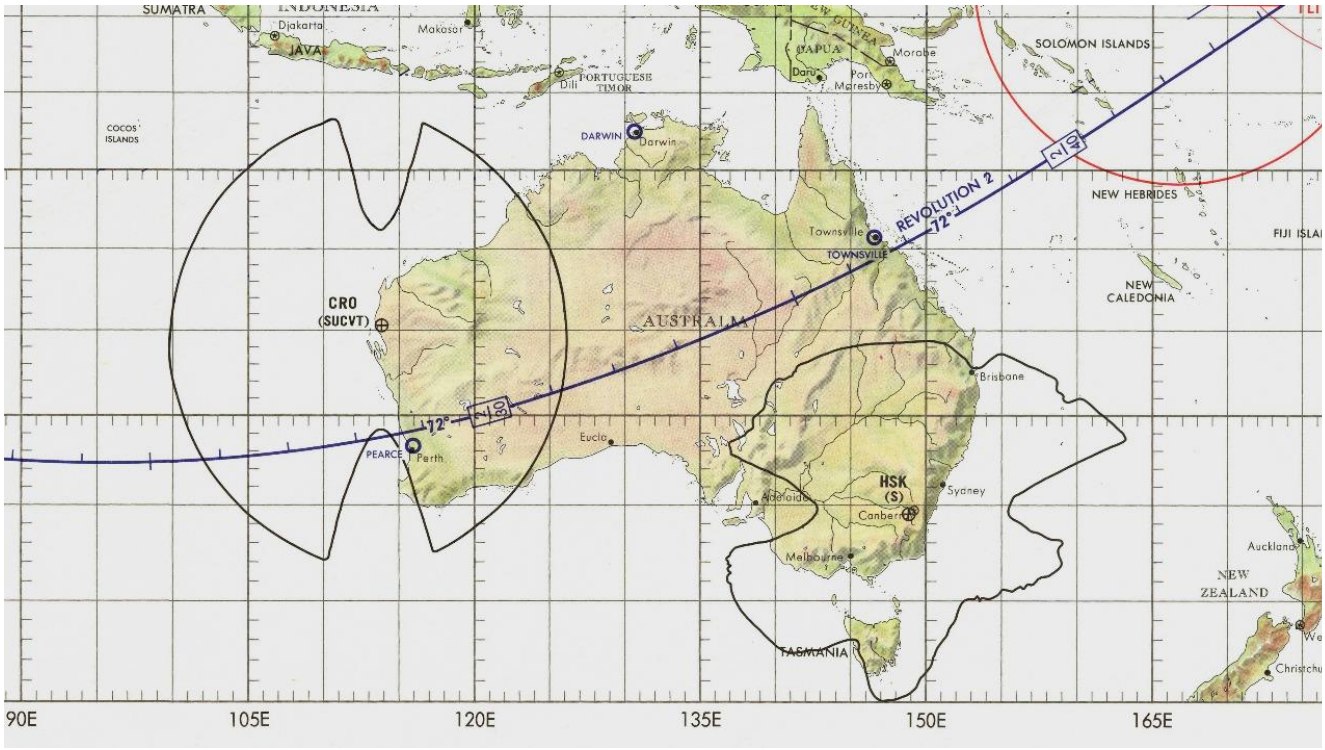
McCandless: "A little over one minute to LOS over Honeysuckle. You'll be AOS at Goldstone at 1:29:02. LOS at Goldstone 1:33:55. Over."

Collins to his crewmates: "Let me tell them about the TV."

Collins to Houston: "Roger, Bruce. Thank you. We expect TV. We've got it all hooked up. We have not yet turned it on.

We're ready to do that now."

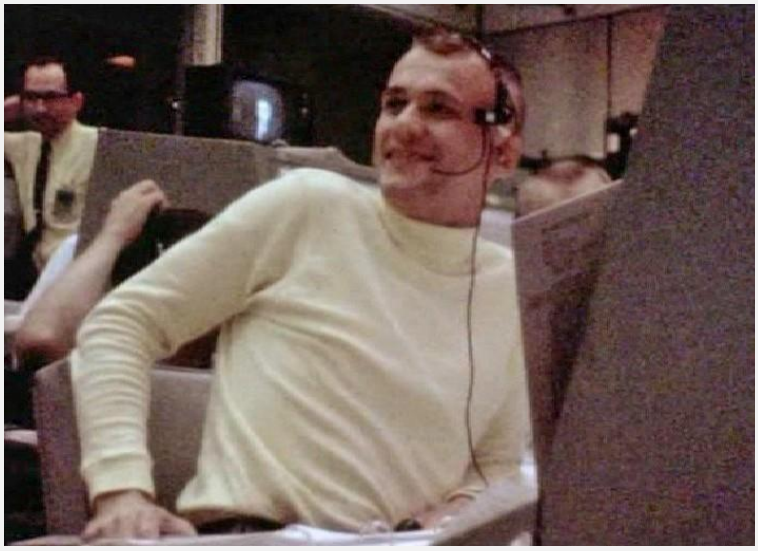
McCandless; "Roger we copy. We'll be configured and waiting for whatever you want to send down."



Apollo 11's ground track across Australia on their second orbit, just prior to the TLI burn.
From the Apollo 11 Earth Orbit Chart.
Scan: Hamish Lindsay.

After leaving Honeysuckle Creek Armstrong offered his crewmates a sweet each. Aldrin declined but Collins accepted with the comment, "Can I give you the wrapping back?"

The second orbit was out of sight below our northwest horizon.



Capcom Bruce McCandless at his console in the MOCR, around the time of TLI.
Screen capture from NASA 16mm footage
by Colin Mackellar.

IT'S "GO" FOR THE MOON

The second orbit over Carnarvon at 0157:30 AEST was the big moment for the Capcom at Houston to tell the astronauts they were to go ahead for the lunar burn.

At 2:25:44 GET McCandless called:

> *"Apollo 11, this is Houston through Carnarvon. Radio check. Over."*

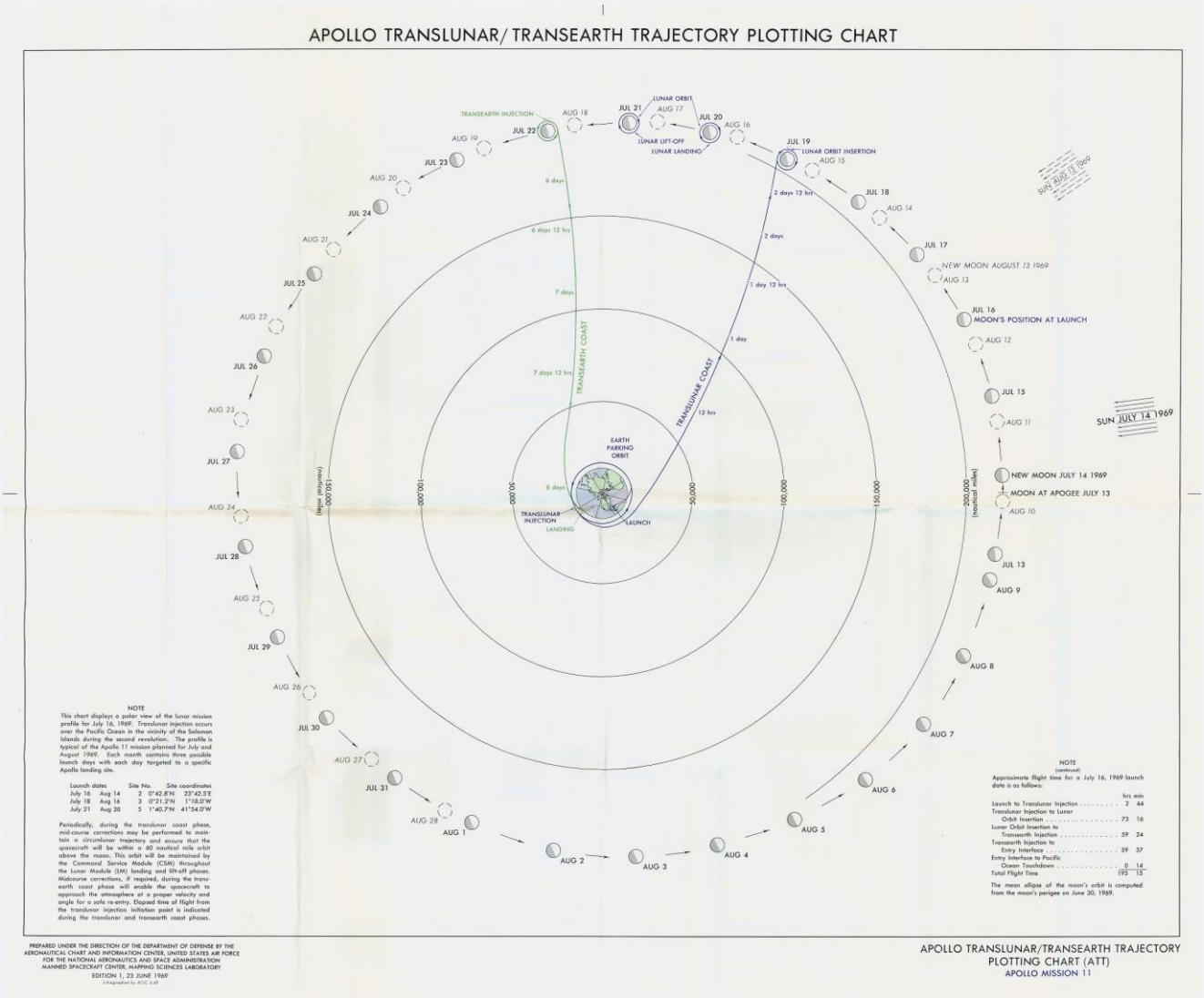
> *"Roger, Houston through Carnarvon. Apollo 11 – loud and clear."*

McCandless, *"Apollo 11, this is Houston. You are go for TLI. Over."*

Collins, *"Apollo 11. Thank you."*

McCandless through an ARIA aircraft flying over the Pacific Ocean at 2:43:18 GET: *"Apollo 11, this is Houston. Slightly less than one minute to ignition and everything is go."*

Armstrong and Collins: *"Roger."*



Apollo 11 Translunar / TransEarth Trajectory Plotting Chart

The legend reads:

This chart displays a polar view of the lunar mission profile for July 16, 1969. Translunar injection occurs over the Pacific Ocean in the vicinity of the Solomon Islands during the second revolution. The profile is typical of the Apollo 11 mission planned for July and August 1969. Each month contains three possible launch days with each day targeted to a specific Apollo landing site.

Launch dates		Site No.	Site coordinates	
July 16	Aug 14	2	0°42.8'N	23°42.5'E
July 18	Aug 16	3	0°21.2'N	1°18.0'W
July 21	Aug 20	5	1°40.7'N	41°54.0'W

Periodically, during the translunar coast phase, mid-course corrections may be performed to maintain a circumlunar trajectory and ensure that the spacecraft will be within a sixty nautical mile orbit above the Moon. This orbit will be maintained by the Command Service Module (CSM) throughout the Lunar Module (LM) landing and lift-off phases. Midcourse corrections, if required, during the transEarth coast will enable the spacecraft to approach the atmosphere at a proper velocity and angle for a safe re-entry. Elapsed time of flight is indicated during the translunar and transEarth coast phases.

With thanks to Bob Fish, USS Hornet Museum, for the scan. Annotations by Colin Mackellar.

Translunar Injection

At 2:44:16.2 GET (0216:16 AEST 17 July), after 1½ Earth orbits, the Saturn IVB was lit for 5 minutes 46.83 seconds to insert the spacecraft into Trans-Lunar Injection (TLI) at 02:50:13 GET (0222:13 AEST) and send Apollo 11 off to the Moon at 39,003.5 kilometres per hour.

Unseen in the darkness below, ships stationed in the Pacific, and Apollo Range Instrumented Aircraft (ARIAs), were following every move made by the spacecraft and reporting back to Mission Control in Houston.

TRANSLUNAR COAST (TLC) Day 1

HSK Prime

AOS: 0957 AEST

LOS: 2045

Track Duration: 10h 48m

TV on at acquisition LOS TV: 1021

Television: 24m

Handover uplink HSK to MAD: 2032 AEST

2-way duration: 9hrs

HSKX Wing (Tidbinbilla)

AOS: 1040:00

LOS: 2045

Track Duration: 10h 5m 0s

Honeysuckle Creek did not see the TLI burn that pressed the astronauts into their couches with a force of 1g as they broke away from a circular Earth orbit. They rapidly gained altitude, heading towards the dawn.

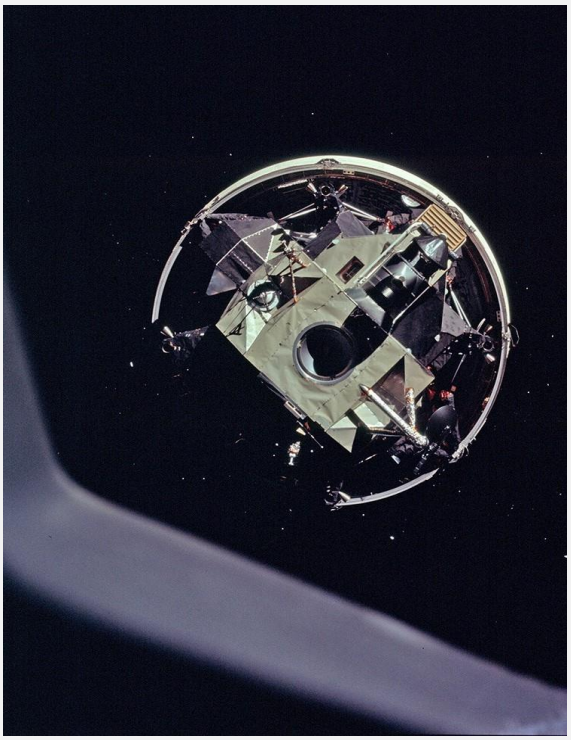
Armstrong described how he felt leaving the Earth:

"The engine comes to life; you settle back in your seat; you feel the strong push of that rocket in your back – but in the dark you just can't see what's happening. There's no visual confirmation. The engine stops and you're floating again. You see a scimitar of light ahead – a sliver of daylight marking the dawn and you are flying back into daylight. In a half minute you are smothered in daylight – it's overwhelming. You are moving outward from Earth at ten times the speed of a rifle bullet, but you seem to be perfectly motionless. The horizon is growing more and more; you can see Australia off to the right and Japan off to the left. All of a sudden you can see the entire circle – the whole planet Earth exploding away from you into the inky black sky…"

At 2:53:03 GET (0225:03 AEST) Armstrong praised the rockets that boosted them off the Earth:

> *"Hey, Houston, Apollo 11. That Saturn gave us a magnificent ride."*
>
> McCandless, *"Roger 11. We'll pass that on. And it certainly looks like you are well on your way now."*
>
> Armstrong, *"We have no complaints with any of the three stages on that ride. It was beautiful."*
>
> McCandless, *"Roger. We copy. No transients at staging of any significance? Over."*
>
> Armstrong, *"That's right. It was all… all a good ride."*

They were on their way to rendezvous with the Moon, 350,980 kilometres away at that moment.



Eagle, nestled atop the S-IVB
as Columbia moves in for docking.
NASA photo AS11-36-5313 / Apollo Image Archive.

At Honeysuckle Creek, our first contact with the spacecraft came at 7 hours 34 minutes after they had left Earth orbit. They had already established a PTC (Passive Thermal Control) roll of 0.3° per second to even the temperatures around the spacecraft.

Also out of Honeysuckle Creek's view, the first task for the astronauts was to turn the CSM around and dock with the LM, still nestling in its housing at the end of the Saturn IVB. Collins backed the CSM about 30 metres away before turning around. As he brought the two vehicles gently together at 0256 AEST, he noticed the LM's flimsy aluminium skin was so thin it rippled to the bursts of gas from the Command Module's control jets like a breeze across long grass.

The two-spacecraft mated together, the twelve latches clamped tight, and Collins clambered down to remove the hatch before inspecting the tunnel and clamps. After assuring himself that all was in good order, he piloted the CSM/LM combination away from the Saturn rocket, now looking rather forlorn and empty. They went separate ways, the Saturn going off into solar orbit, and the CSM now locked with the LM, heading for the moon.

They unzipped their pressure suits, made difficult in the cramped space. Confusion reigned as odd parts floated about, and three men tried to stuff their bulky suits into storage bags before stowing them away under the centre couch. Then comfortably dressed in white Teflon jump suits, the three sat down to a lunch of beef and potatoes, butterscotch pudding, and brownies washed down with grape punch. During that first day the Moon didn't seem to be getting bigger, but the Earth was visibly shrinking. Although the astronauts were now travelling over 8,690 kilometres per hour away from Earth, they seemed be in a slow-motion zone, as there was nothing nearby to indicate their speed.

At 11:20:00 GET (1052:00 AEST), early in our pass, the astronauts settled down for a sleep period, about 2 hours early, made possible by the cancellation of a mid-course correction. They set up two light mesh hammocks while Collins settled down to take the first shift in the centre seat. He quipped, "What could be better than just floating all the way to the Moon?"

So, at Honeysuckle Creek we kept an eye on a silent spacecraft while the crew slept until the end of our pass.

The crew were up before McCandless called them at 22:50:15 GET (2222:15 AEST) with, *"Apollo 11, Apollo 11, this is Houston. Over."*

Armstrong replied, *"Good morning, Houston. Apollo 11," and the astronauts' day began with the usual technical discussion on the spacecraft status and updates, while our day at Honeysuckle Creek was ending.*

HSK MISSION DAY 2

Friday 18 July 1969

TLC Day 2

HSK

AOS: 1037 AEST

LOS: 2047

Track Duration: 10h 10m

Handover uplink GDS to HSK: 1132 AEST

Handover uplink HSK to MAD: 2032 AEST

2-way duration : 9h

At 25:11:14 GET (0043:14 AEST) back-up Commander Jim Lovell, in a mischievous mood, slid into the Capcom's position and called Armstrong:

"Apollo 11, Houston."

Collins, *"Go ahead."*

Lovell, *"Is the Commander on board?"*

A relaxed Armstrong was listening to some music, *"This is the Commander."*

Lovell, *"I was a little worried. This is the back-up Commander still standing by. You haven't given me the word yet. Are you go?"*

Armstrong, *"You've lost your chance to take this one, Jim."*

Lovell, *"Okay – I concede."*

Trial television show recorded at Goldstone

At 30:28:00 GET (0600 AEST) there was a 50-minute trial television broadcast from the spacecraft using the omni antennas. With no lines up to Houston it was recorded at the Goldstone tracking station for later playback.

Collins asked the Capcom if the medics were watching their heartbeats and explained what they were up to, "We're all running in place up here. You wouldn't believe it."

> Duke, *"I'd like to see that sight. Why don't you give us a TV picture of that one?"*
>
> Collins, *"I think Buzz is trying."*
>
> Aldrin, *"You got it."*
>
> Duke, *"Okay. It's coming in at Goldstone, Buzz. As Bruce said, we don't have it here at the Center."*

Goldstone reported they could see the astronauts trying to run in their seats.

> Duke, *"Goldstoners say they see you running there, Mike."*
>
> Armstrong, *"Ask him what he's running from."*
>
> Duke, *"Mike, we see about a 96 heartbeat now."*
>
> Collins, *"Well, that's about all that is reasonable, without getting hot and sweaty."*
>
> Duke, *"Rog. We copy."*

A Television broadcast showing their life on board the spacecraft

At 33:59:00 GET (0931 AEST) the thermal control rolling (PTC) was stopped to train the high gain antenna towards Earth for a 36-minute television broadcast. It began with a view of the Earth from 238,900 kilometres before moving into the spacecraft interior where they suspended a torch in the air pointing into a dark corner, Armstrong stood on his head, Aldrin demonstrated push-ups and chef Collins dished up a chicken stew, explaining:

> *"Would you believe you're looking at chicken stew, here? All you have to do is – 3 ounces of hot water for 5 or 10 minutes. Now we get our hot water out of a little spigot up here with a filter on it that filters any gases that may be in the drinking water out, and we just stick the end of this little tube in the end of the spigot and pull the trigger three times for 3 ounces of hot water and then mush it up and slice the end of it and there you go, beautiful chicken stew."*

Collins also commented:

> *"We are very comfortable up here, though. We do have a happy home. There's plenty of room for the three of us and I think we're all learning to find our favourite little corner to sit in. Zero g is very comfortable, but after a while you get to the point where you sort of get tired of rattling around and banging off the ceiling and the floor and the side, so you tend to find a little corner somewhere and put your knees up, or something like that, to wedge yourself in, and that seems more at home."*

After the television show the astronauts looked for a laser beam directed at them but failed to see it. They then bunked down for a 10 hour eat and rest period, going to sleep with the sounds of whirring fans and the occasional thump of thrusters keeping the spacecraft's attitude.

Fire at Tidbinbilla Tracking Station

At the Honeysuckle Creek Wing site at Tidbinbilla, the staff were all settled down and looking forward to their key role tracking the LM on the moon's surface. At 1825 AEST on 18 July there was a fire in the power supply of the backup transmitter.

Audio

Moments later, Mike Dinn informs Network in Houston that the Wing is "Red Cannot Support"

200kb mp3 file courtesy Apollo in Real Time

Looking at the damage, they first estimated it would be at least a week's work to repair it. But there wasn't a week left.

Station Director at Tidbinbilla, **Don Gray**,

> "There was a very large autotransformer in the transmitter power supply which controlled the output voltage. It was called a VOLTROL. This component developed a shorted turn, which cooked the secondary. For all money, the transmitter was off the air for days until a spare could be air-shipped from the States.
>
> However, we had on staff a most remarkable technician, Alan Blake. He was an ex-RAN Electrical Artificer Chief Petty Officer who had survived the 1964 Voyager disaster, but only after he had been submersed in the sea to a considerable depth before escaping. He suffered permanent hearing damage and developed claustrophobia.
>
> For those who remember the transmitter power supply cabinet, there was a very narrow space for maintenance crews to gain access to the control components. You could only crawl in, and then had to back out. Alan Blake went into that space, completely stripped the Voltrol secondary, removed the damaged material, and re-built it from scratch. Of course, he had a number of 'go-fers' running to get materials and tools for him, but as I recall he spent something like twelve hours in that confined space. When he finished, we fired up the transmitter and it worked FIRST TIME."

At Tidbinbilla: Don Gray and Alan Blake.
Photo via Mike Dinn, scan Colin Mackellar.

Alan Blake, the Transmitter Field Engineer, told me his story:

> "I had just come down from dinner in the canteen when there was a call on the intercom to say there was a fire in the transmitter power supply. I ran out there, and found dense, thick black smoke was everywhere, and knocked off the circuit breaker and waited for the smoke to clear, then went into the cabinet. There was a horrible mess in there. The temperature had been so hot that the top of the cabinet had buckled. It took quite some time for it to cool down enough to touch it.
>
> The only thing to do was to jury rig the thing to get it back on air. We chopped out all the old chunks of cable loom and made-up new bunches of wires. In the meantime, we pulled out the removable units and there was a queue of blokes from the other subsystems. We gave them the units and drawings and they went down to the store and used anything and everything that could fit in. Ken Cox and I worked through the night, and we had arranged for Geoff Rose to take over the next day. We were down for no more than about 12 hours."

There were some replacement parts required to finish the job, and these were found at Woomera in South Australia. Trans-Australia Airlines (TAA, no longer in business), offered to fly the parts to Canberra. A DC3 flew two wooden boxes containing the precious parts from Woomera to Adelaide where the 0445 AEST flight from Adelaide to Melbourne was held back for more than an hour to collect the parts. In Melbourne, the boxes were transferred to a special flight to Canberra.

Don Gray summed up the episode, "I had many fine moments during my time in the space tracking business, but I can honestly say I never felt prouder of the skilled and dedicated people we worked with than when, after the next day's countdown, the Wing was declared GREEN on the Goddard Space Flight Center's Status Board."

At Tidbinbilla: Ted Wilcox, Ken Cox, Geoff Rose
were key members of the team who worked to get the Wing back on air.
Photos: Mike Dinn and Bruce Window.

Audio

Hear Don Gray speak about the episode in an April 2010 interview. (2.7MB mp3 file.)

from head to foot when they emerged from the Transmitter power supply cabinet.

They were not the only ones involved in that, as much of the componentry was smoke and heat damaged and had to be removed, cleaned and tested before being re-installed.

Keith Aldworth from Tidbinbilla adds:

"I would like to add for the record that what Don Gray said about Alan Blake is very true and Alan was absolutely a hero.

I would also like to mention the two techs who helped him enormously with the task. They were Ted (Stumpy) Wilcox and Graeme Stratford.

They were both small in stature and were able to get inside the power supply cabinet to carry out repairs. I did see the results of the fire just after it occurred, and it was so bad that one would think it impossible to repair. Under the expert guidance and knowledge of Alan, they did an amazing job in getting it up and running is such a short time.

I have memories of seeing both Ted and Graeme covered in black, sooty mess

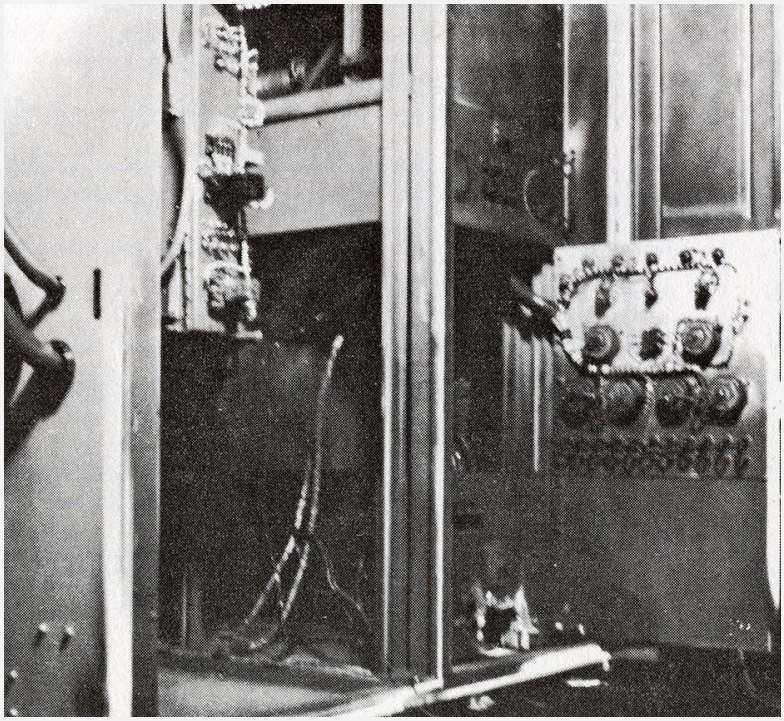


Photo from a JPL Technical Memorandum:
General view of cabinet damage to
transmitter No.2 at Tidbinbilla.

Several other techs were involved in that, and many long hours were spent on the tasks. It stands as an example of the dedication that we all had for what we were doing."

A report from a JPL Technical Memorandum –

On July 18, while Apollo 11 was enroute to the moon, Tidbinbilla/MSFN Wing had a major failure in transmitter power supply 2 at 08:25 GMT while the station was tracking Apollo 11 in a three-way mode. Transmitter 1 was still operational at the time. A fire caused by a short in the primary 460-V, 3-phase system destroyed a large part of the power supply's control system. There was considerable damage to internal wiring, and some melting and fusing of metalwork and panels occurred.

As soon as the power supply had sufficiently cooled, repair crews started to determine the extent of damage and replace the burned components. Fortunately, spares for critical, long-lead time items were at the station. However, additional control circuit components and the primary heavy-duty, 3-phase wire were not immediately available. These were obtained by removing needed components from the obsolete "L" to "S" power supply still situated at the DSN Woomera station, and by airlifting the additional needed components and wiring from the Goldstone DSCC. The station crew, with assistance from the MSFN Prime station at Honeysuckle Creek, worked around the clock to repair the power supply. Full rf power became available on transmitter 2 at 13:30 GMT on July 19. As of that time, 177 manhours had been expended to repair the unit. The unit was then tested under full power until 22:20 GMT on July 19, at which time it was declared operational, and the station reinstated to full Apollo support status. Tidbinbilla supported the lunar landing and Apollo 11's subsequent return to earth without further incident.

– This report and photo (on previous page) appeared on pages 30 and 46 of the JPL Technical Memorandum 33-452 Volume II ("Deep Space Network Support of the Manned Space Flight Network for Apollo, 1969 – 1970") by F.M. Flanagan, R.B. Hartley and N.A. Renzetti. Preserved by Les Whaley, scanned by Colin Mackellar.

HSK MISSION DAY 3

Saturday 19 July 1969

TLC Day 3

HSK

AOS: 1020 AEST

LOS: 2102

Track Duration: 10h 42m

Signal level from the spacecraft: -112 dbm

Handover uplink GDS to HSK: 1332

Handover uplink HSK to MAD: 2042

2-way duration: 7h 10m

PARKES

AOS: 1200 AEST

LOS: 1649

Track duration: 4h 49m

Signal level: -111dbm (s/c on omni antennas)

At 55:08:00 GET (0640 AEST) the crew began a 96-minute colour television session through Goldstone's 64 metre dish, which included interior views of the Command Module and Lunar Module plus views out of the windows with the Earth 324,000 kilometres away. The viewers were treated to watching probe and drogue removal, and the spacecraft tunnel hatch to the LM being opened.

Duke, *"We see lots of arms."*

Collins, *"The only problem, Charlie, is these stagehands don't know where to stand."*

Duke, *"Well, you don't really have a union card there. We can't complain too much."*

Aldrin entered the LM first, followed by Armstrong and viewers were treated to a tour around the LM, with views looking back into the CM. Included were items of interest such as their EVA gear waiting to be used:

Aldrin, *"Inside the helmet visors are the EVA gloves with the blue tips."*

Duke, *"Roger Buzz, that's a great shot now that we're getting of the helmet, the EVA visor and also the EVA gloves in the background."*

Aldrin, *"Okay. You did say this is going out now, didn't you?"*

Duke, *"Eleven, you got a pretty big audience. It's live in the US – it's going live to Japan, western Europe, and much of South America. Everybody reports very good colour. Appreciate the great show."*

Duke, *"Hey, that's a good view of Mr Collins down there. We finally see him again."*

Collins responded, *"Hello there, earthling."*

Equigravisphere

With the astronauts resting, Apollo 11 sailed through equigravisphere at 61:39:55 GET (1311:55 AEST) where the gravity of the Earth equalled the gravity of the Moon. They were 345,281 kilometres from Earth and 62,638 kilometres from the Moon, travelling at 3,280 kilometres per hour relative to Earth and 4,149 kilometres per hour relative to the Moon. At this point Mission Control computers and displays changed from earth to lunar referenced parameters.

HSK MISSION DAY 4

Sunday 20 July 1969

Lunar Orbit Insertion burn

75:49:50 GET, 0321:50 AEST
Initial AOS (Orbit 4): 1048
Final LOS (Orbit 9) : 2107:30
Track Duration: 10h 19m 30s

When the Moon rose above the horizon on Sunday at Honeysuckle, Apollo 11 was already on its fourth orbit.

HSK Prime CSM Lunar Orbits

Orbit			Track Duration
4 AOS: 1048:00	LOS: 1115:40		27m 40s
Signal level: -103 dbm			
5 AOS: 1202:03	LOS : 1314:01		1h 11m 58s
6 AOS: 1402:45	LOS : 1312:21		1h 09m 36s
7 AOS: 1558:42	LOS : 1710:45		1h 12m 03s
8 AOS: 1757:16	LOS : 1909:08		1h 11m 52s
9 AOS: 2001:30	LOS : 2107:30		1h 06m 00s

Total Track Duration: 6h 25m 09s

HSKX Wing LM

Orbit			Track Duration
4 AOS: 1053:00	LOS: 1225:00		1h 32m 00s
Signal level: -102 dbm			
5 AOS: 1202:03	LOS : 1314:01		1h 11m 58s
6 AOS: 1402:45	LOS: 1312:21		1h 09m 36s
7 AOS: 1558:42	LOS: 1710:45		1h 12m 03s
8 AOS: 1757:16	LOS: 1909:08		1h 11m 52s
9 AOS: 2001:30	LOS: 2107:30		1h 06m 00s

Total Track Duration: 7h 29m 29s

Parkes

Orbit			Track Duration
5 AOS: 1240:00	LOS: 1314:01		1h 11m 58s
Signal level : -88 dbm			
6 AOS: 1407:15	LOS: 1518:21		1h 11m 06s
7 AOS: 1558:42	LOS: 1710:45		1h 12m 03s
8 AOS: 1757:16	LOS: 1909:08		1h 11m 52s
9 AOS: 2001:30	LOS: 2107:30		1h 06m 00s

Total Track Duration: 5h 52m 59s

During the fourth day Collins swung the CSM around to look at the Moon. Not having seen it for a whole day the three astronauts were startled by its size – it filled their windows like a huge three-dimensional balloon suspended in space, so close they felt they could reach out and touch it. Brilliant sunlight splashed around the rim, while below them the crater-studded surface brooded in a darkness lit by the eerie glow of earthshine.

While they were finishing breakfast the windows darkened as they entered the Moon's shadow, and all the stars came out. Armstrong called back:

> *"Houston it's been a real change for us. Now we are able to see stars again and recognise constellations for the first time on the trip. The sky is full of stars, just like the nights out on Earth. But all the way here, we've only been able to see stars occasionally, and perhaps through the monocular, but not recognise any star patterns."*

INTO LUNAR ORBIT
Lunar Orbit Insertion (LOI)

Shortly before the spacecraft was due to go behind the moon for the first time Houston announced, "Eleven, this is Houston. You are GO for LOI, over." The LOI (Lunar Orbit Insertion) burn had to take place behind the moon, out of sight of Earth and the tracking stations.

Aldrin: *"Roger, Go for LOI."*

The crew could see the Moon through their windows:

Collins, "Yes, the Moon is there, boy … in all its splendour."

Armstrong, "Man, it's a…"

Collins, "Plaster of Paris grey to me."

Aldrin, "Man, look at it."

One minute away from LOS behind the Moon, Apollo 11 was 787 kilometres from the Moon and travelling at 8,085.5 kilometres per hour.

McCandless gave a final call, *"Apollo 11, this is Houston. All your systems are looking good going around the corner, and we'll see you on the other side. Over."*

Armstrong, *"Roger. Everything looks okay up here."*

At 75:41:23 GET (03:13:23 AEST) on Sunday July 20 the astronauts could see the lunar horizon coming up as the spacecraft disappeared behind the moon at an altitude of 572 kilometres above the lunar surface and travelling at a speed of 8,409.6 kilometres per hour. Only Madrid was in contact, Goldstone and Honeysuckle Creek were out of sight on the far side of the Earth. The astronauts checked and rechecked the procedure for the rocket burn to put them into lunar orbit for what seemed hundreds of times as just one erroneous digit entered in the computer could turn them around and blast them into orbit around the Sun instead of the Moon.

Collins, "Got B mode…"

Armstrong, "Burning… we're looking good."

At an altitude of 160.6 kilometres and at exactly 75:49:50.37 GET (0321:50 AEST), after a Trans-Lunar Coast that lasted for 73 hours, 5 minutes 35 seconds, they anxiously scanned their displays to keep an eye on the progress of the 5 minute 57.53 second burn to put them into a lunar orbit of 314.3 by 111.1 kilometres.

At the end of the burn Armstrong announced, "Shutdown."

Collins quipped, "Hello Moon, how's the old backside?"

The engine had performed flawlessly. They were safely in lunar orbit.

With the spacecraft out of contact with Earth, Mission Control in Houston went quiet, the subdued flight controllers mainly seated at their consoles, some standing up, an odd conversation taking place. Bill Anders, Jim Lovell, and Fred Haise, the Apollo 11 back up crew arrived, and joined McCandless at the Capcom console. Many of the astronauts, including John Glenn, appeared in the viewing room. They were all waiting for the spacecraft to reappear to confirm the burn had gone to schedule.

The Public Affairs loop announced, "With a good Lunar Orbit Insertion burn, the Madrid station should acquire Apollo 11 at 76:15:29 (GET). Acquisition time for no burn; 76:05:30."

In the spacecraft behind the Moon, the astronauts were astonished at the size of the craters passing by below. As the spacecraft

approached Earthrise, the astronauts were getting ready to photograph the moment:

Collins, "We want the big camera, huh? Big lens or small one?"

Armstrong, "Oh, it doesn't really matter."

Aldrin, "80 millimetre will probably good for…

Collins, "….for the Earth coming up?"

Armstrong, "No, for the Earth…"

Aldrin, "No, for the Earth coming up, we want 250. Might take some..."

Armstrong, "…might take some…some luck to get that."

Collins, "Are you black and white or colour?"

Aldrin, "Colour."

Collins, "Alrighty."

Aldrin, "5.6 at - 5.6 at 1/250th is probably…"

As the Earthrise moment drew near, Collins said,

"Okay, we shouldn't take any more pictures on this roll until Earth comes, I don't think. This is…"

Armstrong, "About out?"

Collins, "… just about out and it's our last colour roll, so we'll switch back to black and white as soon as we get to Earth."

Armstrong, "We might make it in time."

Collins, "Yes."

Aldrin, "There it is… it's coming up!"

Collins, "What?"

Aldrin, "The Earth. See it?"

Collins, "Yes… beautiful."

Aldrin, "It's halfway up."

Armstrong, "We ought to have AOS now.'

Armstrong, "Okay, how about MSFN…"

Collins, Aldrin, "You got them!"

Armstrong, "We're in Omni…"

Aldrin, "Down voice backup."

Armstrong, "Bravo!"

The tracking station at Madrid found the spacecraft signal right on the predicted time of 76:15:29 GET (03:47:29 AEST), the astronauts busy trying to align the high gain antenna for the best angle to Earth as they came over the lunar horizon. Goldstone came into view about 45 minutes later. Houston was anxious to know how the burn to put them in lunar orbit had gone.

McCandless at Houston: "Apollo 11, Apollo 11, this is Houston. Do you read? Over."

Collins, "Houston, Apollo 11. Over." …

[then, after a comm break…]

McCandless: "Apollo 11, Apollo 11, this is Houston. We are reading you weakly. Go ahead. Over."

Aldrin, "Roger. Burn status report follows..."

Aldrin read out the figures, but Houston had trouble copying the report because of the poor signal from the spacecraft.

McCandless, "Apollo 11, this is Houston. Are you in the process of acquiring with the high gain antenna? Over."

Good communication was established with the high gain antenna aligned, and the spacecraft status was passed down by Armstrong. Collins summing the burn report with, "It was like… it was like perfect. "During the second orbit, at 78:20:00

Audio

AOS through Madrid on Revolution 1.

7 minute 15 second / 2.6MB mp3 file, courtesy of The Apollo 11 Flight Journal.

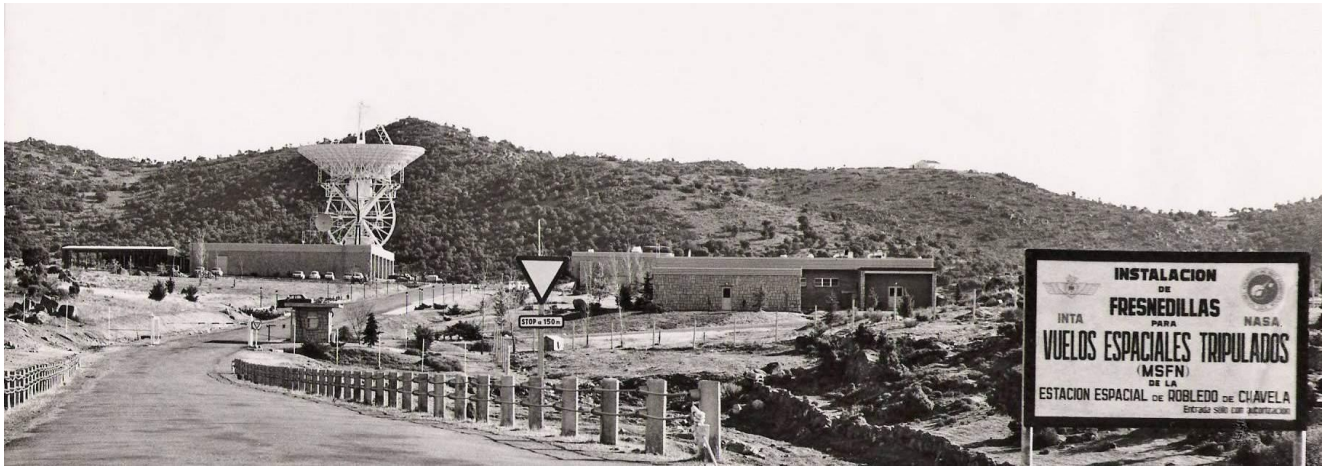
GET (0552:00 AEST), a 40-minute scheduled live colour television transmission was sent to Earth, showing spectacular views of the lunar surface and the approach path to the Apollo landing site #2. As they went behind the Moon:

Aldrin, *"And as the Moon sinks slowly in the west, Apollo 11 bids good day to you."*

Capcom McCandless, *"We thought it was the Sun setting in the east."*

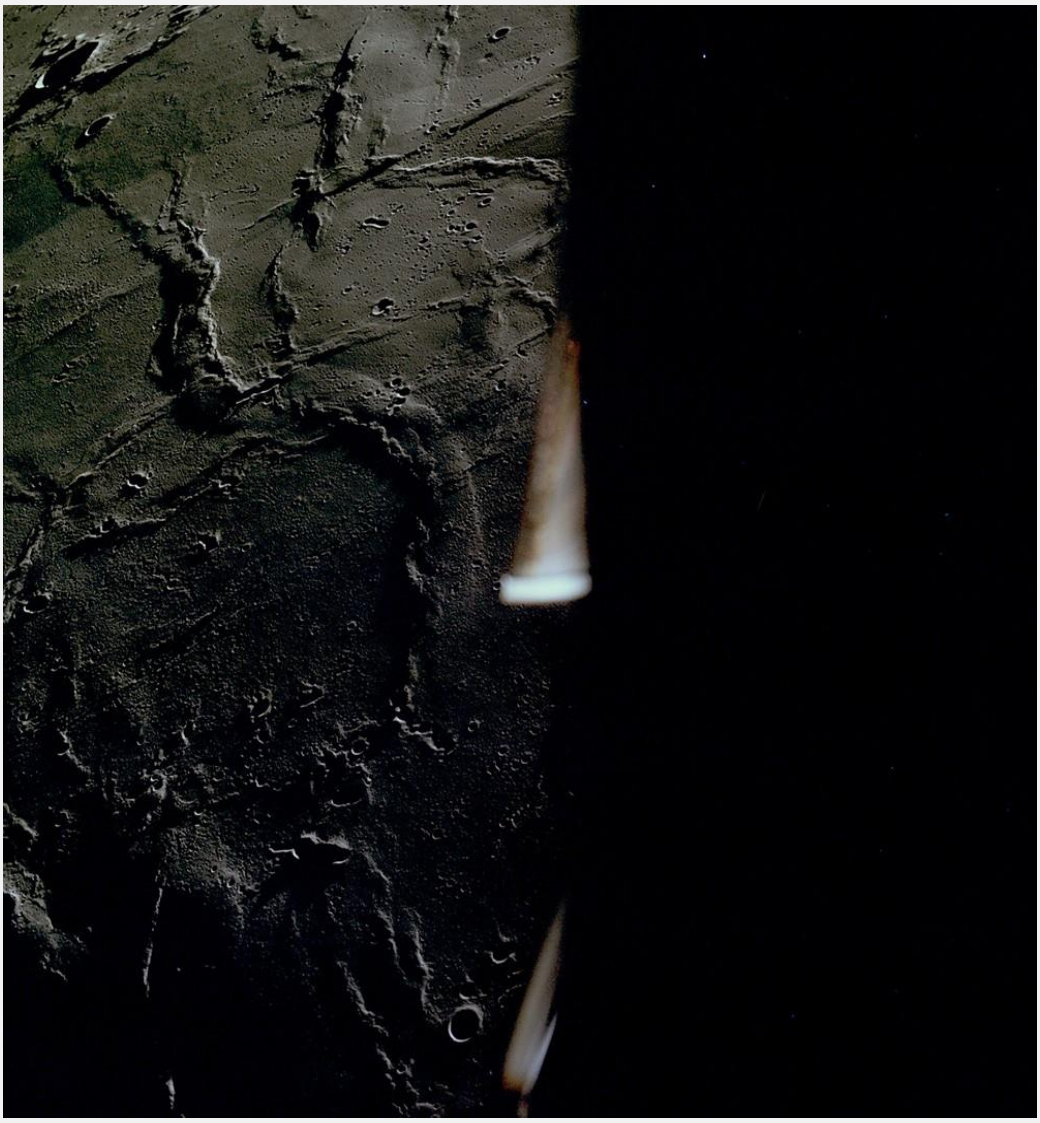
Collins, *"Well, it depends on your point of view."*

After this orbit, while the spacecraft was behind the Moon, astronaut Charlie Duke took over as Capcom, ready for the day's momentous events.



The Madrid MSFN station.
Photo: Larry Haug.

After two revolutions, Collins initiated a second, critical SPS burn of 16.88 seconds at 80:11:36.75 GET (0743:36 AEST) to put them into an elliptical orbit of 122.4 by 100.9 kilometres, ready for the LM to depart for the lunar surface. Critical, because even a burn two seconds too long could put them on a collision course with the other side of the Moon.



The lunar surface illuminated at a very low sun angle.
NASA photo AS11-37-5438 / Apollo Image Archive.

As Apollo 11 approached the Sea of Tranquillity for the first time, the astronauts could see it was early dawn on the surface below them the sun was just tipping the peaks and boulders with a bright glow while long, jumbled, black shadows stretched across the endless craters.

Armstrong and Aldrin were peering through their windows trying to make out the landmarks for the next day's landing, but they were disappointed to find the actual landing site seemed to be in darkness, so they were not able to preview the landing spot.

Armstrong reported his observations:

> "We are currently going over Maskelyne.... and Boot Hill, Duke Island, Sidewinder.
>
> Looking at Maskelyne W that's the yaw-around checkpoint, and just coming into the terminator at the terminator – it's ashen grey.
>
> If you get further away from the terminator, it gets to be a lighter grey, and as you get closer to the subsolar point, you can definitely see browns and tans on the ground."
>
> McCandless: "Roger, Eleven. We are recording your comments for posterity."
>
> Armstrong replied with a laugh, "Okay.... and the landing site is well into the dark here. I don't think we're going to be able to see anything of the landing site this early."

Lunar Module checkout

At 81:10 GET (1742:00 USCDT, late afternoon spacecraft time/ 0842 AEST) Aldrin began procedures to enter the LM to power up and check the spacecraft systems.

> Duke, *"Hello Apollo 11, Houston. We were wondering if you've started into the LM yet. Over."*
>
> Armstrong, *"We have the CSM hatch out, the drogue and probe removed and stowed, and we're just about ready to open the LM hatch now."*
>
> Duke, *"Thank you much, Neil. We'll be standing by."*
>
> At 81:25:53 GET Armstrong announced, *"Okay Charlie, we're in the LM."*

At 81:45:00 GET (0917:00 AEST) the spacecraft went behind the Moon again with the crew sorting out the LM, to reappear at 82:32:00 GET (1004:00 AEST) with limited conversation. Armstrong was planning on shaving his face and Collins was tracking landmarks on the lunar surface.

They passed over the planned landing site and brought up the Lunar Module's power system. At 83:07:00 GET (1039:00 AEST) Houston began receiving data and voice through Goldstone from the LM, and the code name of "Eagle" was used for the first time:

> Aldrin called, *"Houston, Apollo 11 – Apollo 11, Eagle. Over."*
>
> Duke, *"Roger, Eagle. This is Houston. We read you. Over."*

With a successful communications test over the Goldstone station and LOS behind the Moon at 83:44:00 GET (1116:00 AEST) on their fourth orbit, they switched back to CSM power and began to prepare for a rest/sleep period.

By now Honeysuckle Creek was tracking the spacecraft on its first pass of the day, having picked up the signal during the LM communication test as the Moon rose over the horizon.

The next time the spacecraft appeared from behind the Moon it was at 84:30:03 GET (1202:03 AEST) with the crew finishing off preparing the spacecraft for sleeping. Owen Garriott replaced Charlie Duke as Capcom in Houston for the rest period.

At 85:42:01 GET (1314:01 AEST) we lost the spacecraft behind the Moon on its fifth orbit with the astronauts getting ready to go to bed. From the onboard tape recorder:

> Collins, "How'd you sleep last night, Buzz, up on top?"
>
> Aldrin, "Why don't you guys sleep underneath tonight? I'll sleep top deck."
>
> Armstrong, "Oh, you're going to sleep downstairs tonight, aren't you?"
>
> Aldrin, "Yes – that's right, I remember."
>
> Collins, "Unless you'd rather sleep up top, Buzz. You guys ought to get a good night's sleep going into that damned LM."

Collins was offering the two moon walkers the most comfortable sleeping positions – the thought of returning to Earth alone because of an error due to overtiredness was unthinkable.

> Collins then commented, "Well, I thought today went pretty well. If tomorrow and the next day are like today, we'll be safe."

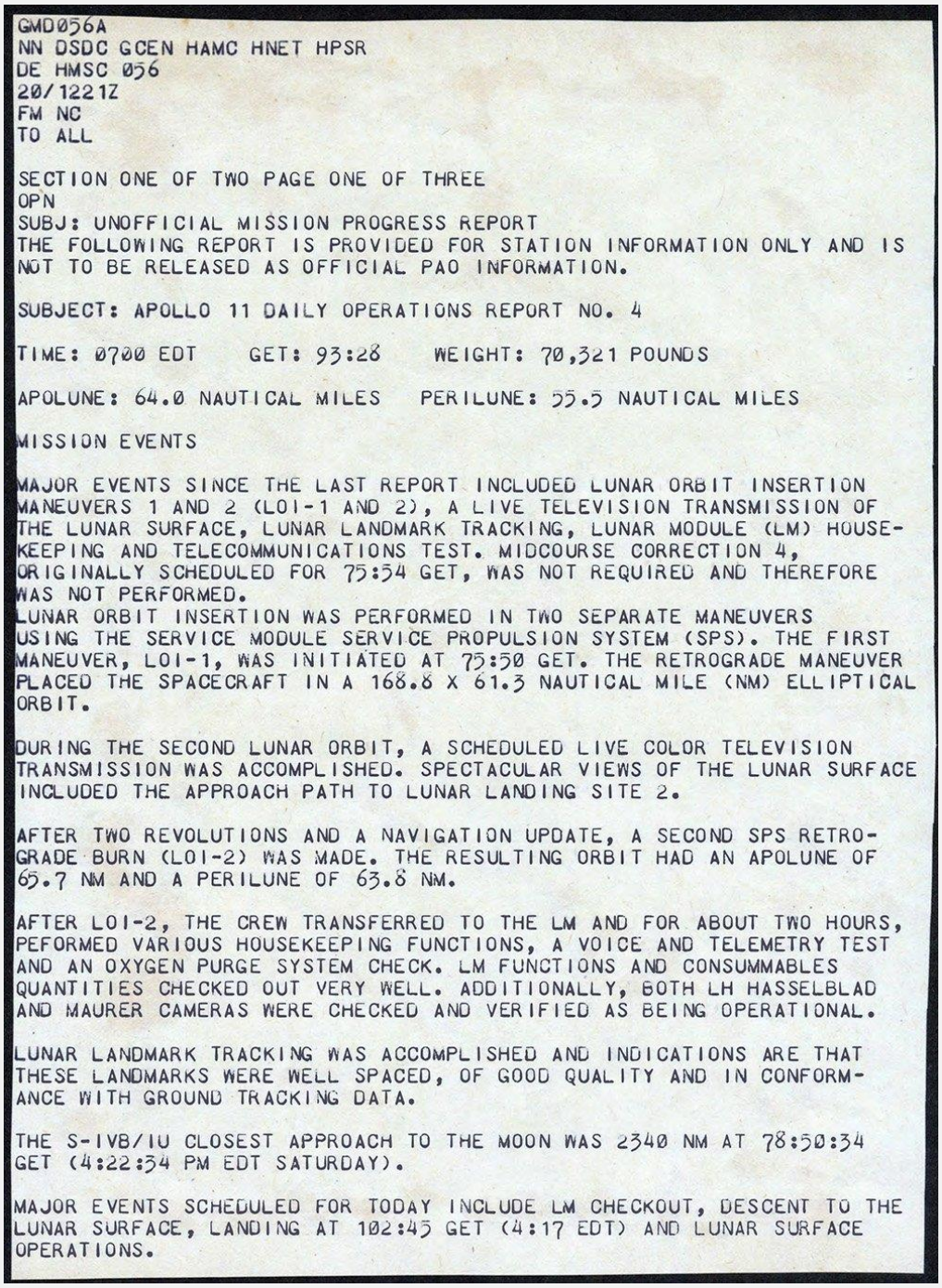
When the Moon rose above the horizon at 83:16:00 GET (10:48 AEST) on Sunday morning at Honeysuckle Creek, Apollo 11 was already on its fourth orbit. At the end of our tracking session, we didn't need a two-way handover with the CSM as

we finished Rev 9 at 93:35:30 GET (2107:30 AEST) and Madrid picked up Rev 10. Goldstone was out of sight on the other side of the Earth.

At 93:32:39 GET, 0604:39 USCDT (early morning spacecraft time/ 2104:39 AEST) during orbit 9, Capcom Evans put in the first call to wake up the astronauts just 2 minutes 51 seconds before Honeysuckle Creek lost them going behind the Moon on our last pass of our day. The crew reported that Armstrong had 5½ hours of good sleep, Collins 6 hours and Aldrin 5 hours. Evans commented, "Looks like you were really sawing them away!" and Collins responded with, "You're right."

A good start to the momentous day.

At 95:20:00 GET (2252 AEST) Aldrin was first into the LM in his undergarments to do some initial checks before returning to the CSM's equipment bay to finish dressing. Half an hour later a fully suited Armstrong crawled into the LM, to be joined by Aldrin and they sealed the hatch before finishing the final checkout.



GMD056A
NN DSDC GCEN HAMC HNET HPSR
DE HMSC 056
20/1221Z
FM NC
TO ALL

SECTION ONE OF TWO PAGE ONE OF THREE
OPN
SUBJ: UNOFFICIAL MISSION PROGRESS REPORT
THE FOLLOWING REPORT IS PROVIDED FOR STATION INFORMATION ONLY AND IS NOT TO BE RELEASED AS OFFICIAL PAO INFORMATION.

SUBJECT: APOLLO 11 DAILY OPERATIONS REPORT NO. 4

TIME: 0700 EDT GET: 93:28 WEIGHT: 70,321 POUNDS

APOLUNE: 64.0 NAUTICAL MILES PERILUNE: 55.5 NAUTICAL MILES

MISSION EVENTS

MAJOR EVENTS SINCE THE LAST REPORT INCLUDED LUNAR ORBIT INSERTION MANEUVERS 1 AND 2 (LOI-1 AND 2), A LIVE TELEVISION TRANSMISSION OF THE LUNAR SURFACE, LUNAR LANDMARK TRACKING, LUNAR MODULE (LM) HOUSE-KEEPING AND TELECOMMUNICATIONS TEST. MIDCOURSE CORRECTION 4, ORIGINALLY SCHEDULED FOR 75:54 GET, WAS NOT REQUIRED AND THEREFORE WAS NOT PERFORMED.
LUNAR ORBIT INSERTION WAS PERFORMED IN TWO SEPARATE MANEUVERS USING THE SERVICE MODULE SERVICE PROPULSION SYSTEM (SPS). THE FIRST MANEUVER, LOI-1, WAS INITIATED AT 75:50 GET. THE RETROGRADE MANEUVER PLACED THE SPACECRAFT IN A 168.8 X 61.3 NAUTICAL MILE (NM) ELLIPTICAL ORBIT.

DURING THE SECOND LUNAR ORBIT, A SCHEDULED LIVE COLOR TELEVISION TRANSMISSION WAS ACCOMPLISHED. SPECTACULAR VIEWS OF THE LUNAR SURFACE INCLUDED THE APPROACH PATH TO LUNAR LANDING SITE 2.

AFTER TWO REVOLUTIONS AND A NAVIGATION UPDATE, A SECOND SPS RETRO-GRADE BURN (LOI-2) WAS MADE. THE RESULTING ORBIT HAD AN APOLUNE OF 65.7 NM AND A PERILUNE OF 63.8 NM.

AFTER LOI-2, THE CREW TRANSFERRED TO THE LM AND FOR ABOUT TWO HOURS, PEFORMED VARIOUS HOUSEKEEPING FUNCTIONS, A VOICE AND TELEMETRY TEST AND AN OXYGEN PURGE SYSTEM CHECK. LM FUNCTIONS AND CONSUMMABLES QUANTITIES CHECKED OUT VERY WELL. ADDITIONALLY, BOTH LH HASSELBLAD AND MAURER CAMERAS WERE CHECKED AND VERIFIED AS BEING OPERATIONAL.

LUNAR LANDMARK TRACKING WAS ACCOMPLISHED AND INDICATIONS ARE THAT THESE LANDMARKS WERE WELL SPACED, OF GOOD QUALITY AND IN CONFORM-ANCE WITH GROUND TRACKING DATA.

THE S-IVB/IU CLOSEST APPROACH TO THE MOON WAS 2340 NM AT 78:50:34 GET (4:22:34 PM EDT SATURDAY).

MAJOR EVENTS SCHEDULED FOR TODAY INCLUDE LM CHECKOUT, DESCENT TO THE LUNAR SURFACE, LANDING AT 102:45 GET (4:17 EDT) AND LUNAR SURFACE OPERATIONS.

A daily report sent to the Network at 93:28 GET. Click image for the full page.
Preserved by Larry Haug, scanned by Bill Wood.

HSK MISSION DAY 5

Monday 21 July 1969

LUNAR LANDING AND EVA

Undocking:
100:12:00 GET, 0344:00 AEST
Only Madrid tracking.

DOI (Descent Orbit Insertion) burn:
102:07:33 GET, 0508:14 AEST

LM Lunar Landing:
102:45:39.9 GET, 0617:39 AEST
Goldstone & Madrid tracking

Selenographic co-ordinates:
0.67409°N, 23.47298°E in the Sea of Tranquillity (Davis et al).

LM Hatch opened:
109:07:33 GET 1239:33 AEST

TV on: 1254:00 AEST

First step on Lunar surface:
109:24:15 GET, 1256:15 AEST

LM Hatch closed:
11:39:13 GET 1511:13 AEST

TV off: 1757:50 AEST

Total EVA time: 2 hours 31 minutes 40 seconds.

HSK Prime

LM	Track Duration
AOS: 1112:00 AEST LOS: 2220:00 Signal level : -112 dbm	11h 08m

Handover uplink GDS to HSK: 1543:00

Handover uplink HSK to CAN (Ascension Island): 2202:00

2-way duration: 6h 19m

Parkes

LM	Track Duration
AOS: 1306 AEST LOS : 1817 Signal level : -90 dbm	5h 11m 00s

HSKX Wing CSM Lunar orbits

Orbit	Track Duration
17 AOS: 1141:08 LOS: 1223:30 Signal level: -103 dbm	42m 22s
18 AOS: 1348:00 LOS: 1451:30	1h 03m 30s
19 AOS: 1537:56 LOS: 1648:50	1h 10m 54s
20 AOS: 1736:13 LOS: 1848:05	1h 11m 52s
21 AOS: 1934:30 LOS: 2046:28	1h 11m 58s
22 AOS: 2132:50 LOS: 2244:45	1h 11m 55s

Total Track Duration: 6h 32m 31s

THE LANDING

In Mission Control, the White Team of flight controllers under Gene Kranz drifted into the control room while in the spacecraft the astronauts were eating their breakfast. Capcom Charlie Duke was already at his console. As their eyes adjusted to the dim lights, the smell of stale cigarette smoke mixed with discarded fast foods struck their nostrils. A low buzz of conversation supported the subdued feeling of urgency in the air as Glynn Lunney's shift briefed Kranz's team. By now every available audio outlet had a headset plugged into it. To be in the operations centre and not have access to the spacecraft communications loop to hear what was going on would be unbearable.

Kranz set himself up at the Flight Director's console and checked out his team. They were all young men – their average age was 26 years. Every position called "GO"; the worldwide tracking network was Green.

As Kranz said, "We were about to write the book on how to land on the Moon".

One of many photos of Eagle taken by Mike Collins during his visual inspection of the LM. Neil Armstrong is just visible in the Commander's window.
NASA photo AS11-44-6598 / Apollo Image Archive.

Separation

Behind the Moon, during the 13th orbit and about two minutes before acquisition by Goldstone, Armstrong and Aldrin extended the LM's landing gear, completed their checks and prepared to separate from the CSM.

> Collins, "We got just about a minute to go. You guys all set?"
>
> Armstrong, "Yes, I think we're about ready."
>
> Armstrong, "We're all set when you are, Mike."
>
> Collins, "15 seconds."
>
> Collins, "Okay …… there you go. Beautiful."
>
> Aldrin, "Looks like a good sep."

At 100:12 GET (0344 AEST), 116.5 kilometres above the lunar surface, Collins watched the LM drift away from him and pirouette around for him to inspect it. There was less than four minutes to Earthrise and Houston.

The separation had happened behind the Moon. If all had gone according to the flight plan, the LM and CSM should be coming round the rim separated, the LM at an altitude of 15,000 metres ready to land in about 28 minutes. The first big event was over. From now on everything was going to be happening fast.

Audio

White Team Flight Director Gene Kranz – 5 minutes before the CSM reappears around the Moon's limb.

Flight Director's loop audio courtesy of the Johnson Space Center. Selection and audio processing by Colin Mackellar.

Madrid and Goldstone had AOS at 0546:52 AEST on the 13th orbit, Columbia's signal appearing at the tracking stations about three minutes before Eagle's, but the LM's signal was weak and dropping in and out of lock due to its antenna not being optimised.

Duke, *"Hello Eagle. Houston. We're standing by. Over."*

Collins, to Eagle, *"Now you're looking good."*

Duke, *"Eagle, Houston. We… Houston. We see you on the steerable. Over."*

Armstrong, *"Roger. Eagle's undocked."*

Duke, *"Roger, how does it look, Neil?"*

Armstrong, *"The Eagle has wings."*

Duke, *"Rog."*

To show the busy time these two astronauts were having, apart from flying the LM, Duke then fired two lots of data to be accurately copied down by the LM pilot, their lives depending on getting the figures right. The first was the DOI (Descent Orbit Insertion) PAD figures, giving details of the burn that would take the spacecraft to the lunar surface:

Duke, *"Roger, Eagle. Coming at you with a DOI PAD: 101:36:14.07. Noun 81, minus 0075.8, plus all balls, plus 0009.8, plus - correction, 0057.2, perigee plus 0008.5 0076.4 030, 000 293. Noun 86, minus 0075.9, plus all balls, plus 0009.8. Rest of the PAD is NA. Stand by on your read back. If you are ready to copy the PDI data, I have it for you. Over."*

Then seconds later came the PDI PAD figures, for a series of burns that would be used to return to the Command Module in the event of an abort, after where it says 'PDI abort':

Duke, *"Roger. PDI PAD: TIG 102:33:04.36; 09:50, minus 0002.1; 182, 287, 000; plus 56919. PDI abort, less than 10 minutes, 105:12:30.00. PDI abort, greater than 10 minutes, 103:40:00.00, 107:11:30.00. No PDI plus 12: 102:44:27.00. Noun 81, plus 0122.3, minus all balls, plus 0188.9; 01520, plus 00110, 0225.0. Burn time, 0:46; 000, 190; plus 0118.7, plus all balls, plus 0191.1. Noun 11, 103:31:07.00. Noun 37, 105:12:30.00. Ready for your read backs, Over."*

Aldrin read back what he had just copied down, without an error,

"Roger. Back to Block, and DOI: 101:36:14.07. Minus 0075.8, plus all zeros, plus 0009.8, 0057.2, plus 0008.5, 0076.4, 030, 000, 293; minus 0075.9, plus all zeros, plus 0009.0; NA. Over."

Duke, *"That was a good read back, Buzz. Go ahead, over."*

Aldrin, *"Okay, PDI PAD: 102:33:04.36; 09:50; minus 0002.1; 182, 287, 000; plus 56919. PDI less than 10: 105:12:30.00. PDI abort greater than 10: 103:40:00.00, 107:11:30.00. No PDI plus 12 abort: 102:44:27.00; plus 0122.3, minus all zeros, plus 0188.9; 0152.0, plus 0011.0, 0225.0, 0:46; 000, 190; plus 0118.7, plus 0000.0, plus 0191.1; 103:31:07.00; 105:12:30.00. Over."*

Duke, *"Roger. Good read back, Buzz. Out."*

Next came a 9 second separation RCS burn by the Command Service Module to give the two spacecraft a safe distance apart of about three kilometres, timed for 100:39:52.9 GET (0411:52 AEST).

Collins, *"I think you've got a fine looking flying machine there, Eagle, despite the fact you're upside down."*

Armstrong, *"Somebody's upside down."*

Collins, *"There you go. One minute to TIG. You guys take care."*

Gene Kranz invited Bill Tindall (watching at left) to sit with him during the landing phase. Tindall was an invaluable help in developing procedures, especially for critical phases of the mission.
NASA photo s69-44155. Preserved by Hamish Lindsay, scanned by Colin Mackellar.

Armstrong, *"See you later."*

Collins, *"Thrusting," as his rockets fired.*

Back in the Eagle Armstrong and Aldrin were preparing for their Descent Orbit Insertion (DOI) burn to take them down to the lunar surface. Columbia's radar was checking Eagle and Collins announced, "I've got a solid lock on. I have you at 0.27 miles (500 metres)."

Descent Orbit Insertion (DOI) burn

The DOI burn required a 30 second firing of the descent engine at 101:36:14 GET (0508:14 AEST), putting the LM in a highly elliptical orbit of 108.3 x 14.4 kilometres. At 0546:52 AEST the Command Module's signal appeared from behind the Moon and Madrid and Goldstone locked on to it.

In Houston, the plot boards and console readouts all came alive with good data.

Audio

Hear the Descent and Landing sequence –

As recorded from Net 1 at HSK
(Audio from Goldstone)

The Network Controller's Loop
in Houston.

The Network and FD Loops combined.

Jack Garman's AGC Support console.

Charlie Duke called, *"Columbia, Houston. We're standing by. Over …… Columbia, Houston, over."*

Collins, *"Houston, Columbia. Reading you loud and clear. How me?"*

Duke, *"Rog. Five by, Mike. How did it go? Over."*

Collins, *"Listen, babe – everything's going just swimmingly. Beautiful."*

Duke, *"Great. We're standing by for Eagle."*

Collins, *"Okay – he's coming along."*

Just over a minute later Aldrin called Houston, *"Houston, Eagle. How do you read?"*

Duke, *"Five by, Eagle. We're standing by for your burn report, over."*

Aldrin, *"Roger. The burn was on time."*

Among the flight controllers an uneasy exhilaration began to build, as Kranz noted, "I can finally feel the tension mixed with excitement in the room. The air starts to crackle as we anticipate coming events." He noticed that the paper in his logbook was becoming damp from the moisture from his palms as he scribed events. "We will land, crash or abort. In forty minutes, we will know which."

Kranz decided to have a private moment with his flight controllers and told them to switch to a private conference loop where he spoke from the heart, sharing his feelings of pride with his team, and he would back every call they made.

He then ordered the control room doors to be locked and the Center configured to the military term Battle Short, that is, the main power circuit breakers were all sealed. Nobody could enter or leave the room during this critical period.

Kranz then said a prayer.

Powered Descent Initiation (PDI)

At the low point of 14.4 kilometres of the elliptical orbit Eagle fired the Powered Descent engine with a 12 minute 36.39 second burn at 102:33:05.01 GET (0605:05 AEST). The time of this burn was right on, but the spacecraft position was 7.4 kilometres further downrange than planned, resulting in the landing point being 7.4 kilometres beyond the planned spot.

By now all the flight controllers were pumped up, stretched to the limit, trying to evaluate their ratty data and make decisions on whether their GO was the right decision. With a slight spacecraft attitude change, contact with Eagle improved enough for Kranz to hear the astronaut's final checklist before the astronauts fired the descent engine.

Aldrin called: "Ignition…10 per cent thrust," advising that the engine was operating at 10% of its maximum thrust of 4762.7 kilograms. The burn consisted of a 15 second burn at 10% thrust, increasing to a 40% thrust for the remaining 15 seconds.

Aldrin explained:

> "The descent was divided into three stages, each controlled by its own computer program. The first was the braking phase, which did most of the slowing. Then as the landing site appeared over the horizon, we entered the approach phase where Neil could see where the computer was taking him, and perhaps tell it to take him somewhere else if he didn't like the look of it. Then we entered the terminal phase – where the LM gently descended the final 100 feet or so while Neil flew it like a helicopter to avoid any obstacles that might get in the way.
>
> My job was to support Neil by giving him all the information from the computer."

Altitude 12,200 metres

Aldrin took his eyes off the instrument panel for a moment to look through the window… "And we got the Earth straight out our front window."

The LM's legs were facing the flight path, the astronauts flying backwards unable to see where they were going. They were able to see landmarks passing by so knew where they were as they headed down for the moon's surface, the astronauts looking up at the Earth through the windows. At all times they were very conscious of their home, the Earth a blue and white jewel glittering in the black void of space hanging suspended up there in the lunar sky. The land they were heading for had no water or food or shelter, and the nearest friendly mechanic or technician and their spare parts were three days and over 321,860 kilometres away across the void. No place to have a breakdown.

The LM was now racing horizontally across the lunar landscape at 5,790 kilometres per hour and had to slow up in stages, to the speed of a jet plane, 965 kilometres per hour, down to the speed of a car at 100 kilometres per hour at an

altitude of 2,133 metres, finally hovering above the surface, before dropping vertically into the dust. Armstrong and Aldrin had to make the first ever landing on the moon in one go - there was no way of pulling out for a second attempt.

Altitude 10,200 metres

Aldrin, "We now sensed the real speed of our descent for the first time." They began to feel the Moon's gravity pulling on their arms and bodies, their boots beginning to press on the floor.

At 102:38:04 GET the landing radar indicated it was receiving good signals from the lunar surface and its data was accurate. Then an electrical problem appeared, a bad meter reading the AC power had the controllers worried as the AC system powered the gyro's landing radar. The decreasing height of the LM above the lunar surface was critical now. Their height above the lunar surface measured by our ranging systems in the tracking stations on the Earth could be anything up to 2,500 metres out at lunar distances and angles, so the height measured by the on-board radar was needed at Houston for evaluation and comparison. Kranz had to grapple with an increasing number of problems rearing up as the LM dropped to the lunar surface, "All through this time my mind is really running. Is there enough data to keep going?"

Aldrin, "Communications were difficult and at times it completely broke up. Here we were trying to make a landing on the Moon and at this point we had no clear and instant contact with the flight controllers back on Earth."

Kranz, "This is where it's now time to say are we going down to the lunar surface or not? I only had one wave off opportunity – only one. If I wave off on this powered descent, then I have one shot in the next rev. and the lunar mission is all over. You don't squander your "GO" "NO-GO's" when you've only got one more shot at it. Come right up to the time and we lose all data again. So, I delay the "GO" "NO-GO" with the team for roughly 40 seconds. We got data back briefly and I made the decision to press on."

The tension shows on the face of Capcom Charlie Duke (left), and Jim Lovell, as smoke from Deke Slayton's cigarette (out of view to the left) hangs in the air.
Screen capture from NASA 16mm footage by Colin Mackellar.

Neil Armstrong at the Commander's position in Eagle.
Taken during a pre-mission simulation in the flight crew training building at KSC.
NASA photo KSC-69PC-0318.

Kranz has a final call round his team before ignition:

Kranz: “Got us locked up there TELCOM?”

Puddy: “Okay, it’s just real weak, Flight.”

Kranz: “Okay, how ya lookin’? All your systems GO?”

Puddy: “That’s affirm, Flight.”

Kranz: “How about you Control?”

Carlton: “We look good.”

Kranz: “Guidance – you happy?”

Bales: “GO with Systems.”

Kranz: “FIDO, how about you?”

Greene: “We’re GO. We’re a little low, Flight, no problems.”

Kranz: “Rog. Okay, all Flight Controllers – thirty seconds to ignition.”

In the roll call only the Guidance Officer Steve Bales came online with a doubtful call, “Flight, we’re out on our radial velocity; we’re halfway to our abort limits.”

Kranz tensed when he heard the radial velocity was halfway to abort limits and found it meant the spacecraft was moving a bit faster than planned. The reason was the astronauts had not fully decompressed the tunnel between the two spacecraft – it should have been a vacuum – so when they separated the slight pressure remaining pushed the spacecraft apart with more velocity than planned. As the error remained constant the problem was accommodated, but still meant they were going to land further downrange than planned, in what was expected to be a rockier area.

The rest of the flight controllers called in with a “GO” so Kranz advised Duke, “Capcom – we’re go for powered descent.”

Just when they wanted to tell the LM they were GO for powered descent they momentarily lost contact with the LM and had to relay the message via Mike Collins in Columbia.

Duke: *“Eagle, Houston. If you read, you’re GO for powered descent.” There was silence from the spacecraft. Eagle’s high gain antenna was out of alignment.*

Collins picked up the cue and relayed the message: *“Eagle, this is Columbia. They just gave you a GO for powered descent.”*

Duke: *“Columbia Houston. We’ve lost them on the high gain again. Would you please.... we’re recommending they yaw right ten degrees and try the high gain again..... Eagle, you read Columbia?”*

Aldrin: *“Rog – we read you.”*

Then, quite unexpectedly, at 102:38:22 GET (0610:22 AEST) a yellow caution light winked at the astronauts from the computer control panel. It was identified as a 1202 alarm. It meant the computer was overloaded by irrelevant data from the rendezvous radar, which should have been switched off, and couldn’t do all the tasks in the time available.

Armstrong warned the flight controllers at Houston, *“Program alarm.”*

Duke, “It’s looking good to us, over.”

Armstrong, “It’s a 1202.”

Suddenly Steve Bales, a specialist in the computer systems and its alarms deep in the bowels of the LM, was now sitting in the hot seat. He had to decide whether to go ahead and land or abort. At this moment, the lives of Armstrong and Aldrin were in his hands. The success of the mission now depended on his response.

Capcom Charlie Duke said of that moment, “When I heard Neil say 1202 for the first time, I tell you my heart hit the floor. I looked across at Steve Bales, but he was busy at his console and came back with the answer almost straight away we were go.”

Jack Garman is second from the left (wearing a coat) in this 1969 view of the AGC Staff Support Room in Building 30 at MSC Houston.
From S-69-34209, courtesy Jack Garman.

Jack Garman, a young back-room expert supporting Bales from another console, remembered a similar problem had been tried out in a simulation only a week or so before, quickly reassured Bales: "It's executive overflow; if it does not occur again, we're fine."

Audio

Hear a 2014 interview with Jack Garman.
Part 1 (13.3 mins) Part 2 (20.7 mins)

Twenty-six-year-old Steve Bales recalled that fateful moment:

> "I had just started to relax a little bit, if you can call it relaxing, and I heard the program alarm, and quite frankly, Jack, who had these things memorised said, 'that's okay', before I could even remember which group it was in… I was frantically trying to look down… by the time I looked at the group and saw which one the alarm was in, Jack said it's okay, I remembered yeah, that's one of those we said it's okay, I looked up, the rest of the computer looked good, so I said 'Let's go!' It took us a long time. In the Control Center any more than three seconds on descent is too long.... and it took us about ten to fifteen seconds."

The Apollo Lunar Surface Journal reminds us that during a simulation before Apollo 11 Dave Scott

and Fred Haise experienced a 1201 alarm coming into land and Houston aborted the mission. Aldrin commented that:

> "Where some similar things had come up, and Kranz instructed his people to go back and look at these sorts of things. But, as best as I can recall, whatever the flight director people had known about this alarm potential coming up and which were Go and which were not, I was the kind of systems guy, and I was not aware of that. I was very much in the dark when this came up."

After the simulation fright, Kranz insisted that Bales write down every alarm that could possibly go off. Bales promptly passed the task over to Garman, who produced a handwritten sheet which they stuck under the console desk glass for quick reference. Looking at the list Garman spotted the 1202 alarm and thought, "Right, if it doesn't occur too often, we're fine."

With four minutes to go to the landing, the signal from the spacecraft strengthened, and settled down, so from this point on communications with the LM were solid.

Aldrin was apprehensive,

> "I knew there had to be something seriously wrong with our guidance computer and yet we were still descending. They had dismissed the alarm as non-critical, but they couldn't take the time to explain why."

Swiftly dropping down to the Moon's surface the astronauts sweated out a thirty second pause while at Mission Control Kranz snapped out a final tense roll call around his flight controllers. Steve Bales' decision alone decided the fate of the mission, to abort and terminate the mission then and there, or continue onto success or... the possibility of a disaster. As it turned out it was the right decision, and Bales later collected his Medal of Freedom from the President along with the astronauts.

In the middle of the 1202 crisis, Chuck Deiterich in Retro chopped in: "Flight, Retro."

Kranz: "Go Retro."

Deiterich: "Throttle down 6 plus 25."

Kranz to Duke: "Six plus twenty-five."

Retro was advising Kranz to pass on to Duke that 6 minutes 25 seconds into the burn the crew should expect the engine to throttle down to 55 per cent power.

> Duke: *"Roger. We got you. We're go on that alarm... six plus 25 throttle down."*
>
> Armstrong: *"Throttle down on time."*
>
> Aldrin: *"Wow! Throttle down on time! You can feel it here when it throttles down. Better than the simulator."*
>
> Duke: *"You're looking great at 8 minutes."*

Altitude 2,800 metres

Now the LM began to drop its legs to point down to the moon's surface, and the astronauts could see the moon's surface in the bottom of their windows.

Armstrong was trained to land the LM. The two pilots had to work together as a cohesive team, Armstrong controlling the spacecraft's flight while looking out of the window at the landing site; Aldrin concentrating on the display panel and calling out the information he needed. Armstrong had to translate what he saw with what he heard with what he felt to the spacecraft controls to guide the Eagle safely down to the lunar surface.

> Armstrong: *"Okay. 5000 (feet). 100 feet per second is good. Going to check my attitude control. Attitude control is good."* (The 100 feet per second is the descent rate.)
>
> Duke*: "Roger. Copy. Eagle, Houston. You're GO for landing. Over."*
>
> Armstrong: *"Okay. 3000 at 70."*

At 610 meters above the lunar surface another alarm winked from the computer, "1201," said Aldrin with growing concern, "I licked my dry lips. This was a time for discipline. But the tension had me rigid in my suit. We had to trust Mission Control," – there was no time for explanations.

Armstrong: *"1201! Okay, 2000 at 50."*

Duke: *"Roger, 1201."*

In Mission Control Kranz queried Bales again: "1201 alarm?"

Bales had already been onto Garman who urgently yelled into his microphone, "Same type!"

Flight Director Gene Kranz gives Capcom Charlie Duke the "Go for landing" call to pass to the crew.
Screen capture by Colin Mackellar from NASA 16mm film.

and Bales called Kranz: "Same type, we're GO, Flight."

Kranz to Duke: "Okay, we're GO."

> Duke: *"1201 alarm. We're GO. Same type. We're GO."*
>
> Aldrin: *"2000 feet. 2000 feet"*
>
> Duke: *"Eagle looking great. You're GO..... Roger 1202. We copy it."*

While the LM was searching for a landing spot Kranz noted, "My voice loops become silent, the atmosphere electric as we hang on to each of the crew's words." The flight control team had met all their criteria and could do no more for the landing and could only listen to the terse dialogue from the spacecraft.

Armstrong was riveted to his controls. He gave me this description of the last moments to landing from a lecture he gave to members of the American Society of Experimental Test Pilot's Proceedings in 1969:

> "Now we get to that final landing phase, and this is altitude versus range to the landing site. This is about the last ¾ of a mile into the touch down spot from a thousand feet (305 metres). This part is normally flown automatically and as you get down to 500 feet (152 metres) you have some options as to what you can do to complete the landing. One is to just leave the thing run automatically. Then there's several manual options that you can choose from. One is manual attitude control but with an automatic throttle that will control the descent rate to the programmed value that it thinks it should have. One is manual attitude control with a rate of descent mode on the throttle so that you can command your descent rate and it'll freeze. Say you're coming in at 17 feet (5 metres) per second, it'll hold 17 feet per second down until you put a blip on the switch

Capcom Charlie Duke (left) gives the *"We're GO. Same type. We're GO."* call on the 1201 alarm.
Screen captures by Colin Mackellar from NASA 16mm footage.

and each blip changes your rate of descent mode by one foot (0.3 metre) per second. I really didn't think that was likely to work, but it did. Matter of fact, it was quite smooth.

The final method that you have is manual attitude and manual throttle. Just hand on throttle like most of our rudimentary VTOL (Vertical Take Off Landing) aircraft and like you would fly a helicopter. Now, you could fly auto, but it's not likely that many test pilots would do that. One reason is that the auto system doesn't know how to pick a good area and can't change its mind. The second is that when you get right down to the final phases, and it turns out there is a little residual velocity of a couple of feet per second sideways you'd have a bad case of stubbing your toe on touch down. For those reasons, I didn't intend to make an automatic landing; it was my intention to fly the manual mode with this one foot per second incremental rate of descent mode on the throttle into touchdown, which is what I did.

But as we got to the point where you'd normally take over manually, I had been looking out the window and, if you had been listening at the time, all we really saw was a gigantic crater and lots of very big rocks a very unfavourable position to land. Now it looked like we might be able to land short and I was really tempted for a minute because I knew the scientists would have a ball if we could land in the middle of that boulder patch. They would think it was just Jim Dandy if we could run up on the rim and take pictures down the sides of this really big crater and be overjoyed; and I thought about that for a little bit and I didn't do it. It's an old rule, when in doubt, land long, and I did. We extended the range down about 1,100 feet (335 metres) past where it would have gone if we had let it go automatically.

I didn't have any of those 30 storey rocks that Tom (Stafford from Apollo 10) looked at, but I thought that this area with all those automobile sized rocks wasn't probably a good

Jim Lovell (Apollo 11 Backup Commander, centre)
and Fred Haise (Backup LM Pilot) are with Charlie on the console.
Screen captures by Colin Mackellar from NASA 16mm footage.

> place for me to try and join them. Well, I thought this was a good spot and then I got closer and decided it wasn't, so I changed the descent rate and changed the attitude and went on a little bit further and thought this was a good spot, and when I got closer, I was dissatisfied and was just absolutely adamant about my God-given right to be wishy-washy about where I was going to land."

Back in the Mission Control Center in Houston the flight controllers were quiet, there was little they could do now, but they were getting jittery – why wasn't Armstrong landing? He should have landed by now, he always had in the simulations. There were no clues coming down the voice channel, just figures from Aldrin. They were all staring at their consoles, helpless, not one of them knew why the Eagle was still weaving about above the surface, but all were acutely aware that time and fuel were fast running out.

At a height of 76 metres Aldrin flicked a glance out of his window and had a fleeting impression of the LM's shadow on the lunar surface ringed with a halo of bright sunlight before an amber warning light came on only 5 per cent fuel remained and they still weren't down. There were only 94 seconds left to land.

Kranz remembers,

> "That really grabbed my attention, mainly because during the process of training runs we had generally landed by this time. Now it was a question of continuing the countdown. It was a horse race between running out of fuel or getting down on the surface."

At an altitude of 15 metres, they entered what was referred to as the deadman zone. In this zone, if anything had gone wrong if for example, the engine had failed it would probably have been too late to do anything about it before they crashed

on the moon. There were no fail-safe abort systems available until after the landing.

From out of the black sky above the paste white lunar surface bathed in the contrasty early morning sunlight, the LM appeared with a stream of exhaust gases blasting down at the surface. Armstrong noticed that they were beginning to disturb the dust at a height of about 30 metres and he began to have difficulty gauging their velocity by observing surface features.

Like a prehistoric predator, its two windows like beady eyes above the four dangling legs, the LM now hovered 9 meters above the surface, instruments and astronauts desperately searching, trying to probe the lunar dust for a clear spot to land. Armstrong was suddenly aware that the LM was yawing to the left and going backwards, "I arrested the backward rate, but I was unable to stop the translational rate." He could see small boulders and rocks sticking up out of the blanket of dust blasting away from their rocket motor. A hard white surface appeared through the dust, followed by black shadows of the approaching legs and spindly probes.

Deke Slayton was desperate to hear what Buzz Aldrin was saying and felt Duke was talking too much so clipped him on the arm and said, "Shut up," and concentrated on his earphones where Aldrin was reciting displays and events displayed on the console in front of him:

> "six...forward..... lights on .... down two and a half.....forty feet..... down two and a half..... kicking up some dust .... thirty feet ..... two and a half down ..... faint shadow ..... four forward ..... four forward ... ….drifting to the right a little..... .Okay....."
>
> Aldrin: *"4 forward. 4 forward. Drifting to the right a little. 20 feet, down a half."*
>
> Duke had to break in, *"Thirty seconds...."* to advise the crew how much fuel they had left.

Kranz:

"We escalated another notch when we got the 30 second call. The next thing we would start doing would be to call down every second from 15 seconds on down the line. No matter what happened, I was not going to call an abort....."

Everyone was waiting for the 15 second call. Back-room guru Bob Nance was monitoring Armstrong's throttle control positions and was frantically mentally calculating his fuel usage to the amount of fuel remaining.

Armstrong:

> "Well, they called 60 seconds from the ground, and they called 30 seconds, and I heard that, and the next thing I was supposed to see was the contact light, but I never did see that that blue light. They tell me it did come on, and Buzz saw it and he called it, but I never saw it. I was all eyeballs out the window at that point. You know we had some problem with dust the exhaust kicking up dust and it obscured the surface and made it a little difficult because it was flying off parallel to the ground at a very shallow angle and at very high speed, like ground fog. You could see through it, you could see craters and rocks through it and if you had been expecting it, and I should have been, we probably would have neglected it. I'm sure the next crews won't have that kind of problem. In fact, it did confuse us a little bit. Although it didn't affect the altitude determination very much, I did have trouble figuring out what my cross range and down range velocities were, and I didn't want to stub my toe on touch down.
>
> We were supposed to take over about 3:30 in the count down and get a low-level light, which occurs when you have about 5% of fuel remaining and touch down right about the same time. Well, we took over just a little bit late and got the low-level light on time I saw that. That gives you about 94 seconds of flying time left at that point. You have to save the last 20 seconds for an abort. We're flying in a dead man's curve down here close to the ground. If the descent engine quits, the ascent engine is unable to be ignited to go through its ignition sequence and get you back on a safe abort before you hit the surface. So, we were, of course, saving those last 20 seconds so that if we did need to abort, we could 'hang the chili to it' as they say in Texas, and get out of there while we still had the big powerful descent engine. Then when we ran out of fuel, we could stage, and have plenty of time to get going with the smaller 3,500 lb thrust ascent engine.

Now I deviated from the plan here a little bit. Our idea was that we were going to get to 5 feet (1.5 metres) and let those probes the ones sticking out the bottom of the Lunar Module's legs touch the ground. They light a blue light in the panel. Then I was going to go about another second which would get me down to about 3 feet (0.9 metres), say I was coming down about 2 feet per second, and then I'd punch the stop button. Now it's been against my grain to shut off the engine when I was in the air, but it was supposedly an important thing to do because it would prevent the engine from blowing up as it got very close to the surface, or it would avoid overheating of the bottom of the Lunar Module. Also, if we hit hard enough, we would collapse those struts so that the stair steps on the front would be close enough to the surface so we could get comfortably down.

Well, I forgot all that when I got down and actually touched down at a very low velocity very much like what you'd be used to in a normal helicopter landing. Turned out the thermal effects weren't so bad, and the engine didn't have any problem and it was a long way from the top stair down to the surface, but we were able to make that three and a half feet (one metre) or so."

TOUCHDOWN

''The Eagle has landed!''

Just before touchdown Armstrong noticed a tan haze obscuring the horizon, then he saw the shadow of the LM stretching about 60 metres out in front. In a maelstrom of dust, shadows, legs, and spent gases, the spaceship Eagle from Earth gently touched down on the lunar surface at 102h 45m 40s GET, 1517:40 USCDT (spacecraft time) on 20 July (0617: 40 AEST 21 July 1969.)

Aldrin: *"Contact light!"*

Armstrong: *"Shutdown."*

Aldrin: *"Okay. Engine stop."*

Aldrin:

"At ten seconds we touched down on the lunar surface. The landing was so smooth I had to check the landing lights from the touchdown sensors to make sure the slight bump I felt was indeed the landing. It was. I immediately began preparing the LM for a sudden abort ascent in the event the landing had damaged the Eagle, or the lunar surface was not strong enough to support our weight."

Duke: *"We copy you down, Eagle."*

When Armstrong shut the engine down, he was amazed to see all the dust particles stirred up by the engine exhaust just suddenly vanish. "I was absolutely dumbfounded when I shut the engine off and the particles of dust that were going out radially from the bottom of the engine bell all the way out over the horizon just instantaneously disappeared. I had never seen anything like that." This was due to the lack of an atmosphere.

Armstrong had landed the Eagle with negligible forward velocity, slewing 0.6 metres per second to the left, and dropping 0.6 metres per second vertically. The right and forward landing gear touched almost simultaneously, giving a roll-left and coming to rest with a tilt back of just 4½°. Apollo 11 had the least deviation from vertical of all the lunar modules to land on the Moon's surface.

On reflection Armstrong admitted the computer readouts were very helpful,

"The computer data seemed to be pretty good info, and I would say that my visual perception of both altitude and altitude rate was not as good as I thought it was going to be. In other words, I was a little more dependent on the computer information," and decided his perception was much better on Earth.

Armstrong said after,

"The landing was far and away the most complex part of the flight. The systems were heavily loaded at that time. The unknowns were rampant. The systems in this mode had only been tested on Earth and never in the real environment. There were just a thousand things to worry about in the final descent. It was hardest for the system, and it was hardest for the crew to complete that part of the flight successfully."

Suddenly all the gut-wrenching, urgent decisions were gone – just silence. They had landed safely with a 4.5° tilt from vertical and a 13° yaw left

from the flight path. Only fuel for 45 seconds of burn time was left in the tank, “We’d been told to expect the remaining fuel in the descent stage to slosh back and forth after we touched down, but there simply wasn’t enough reserve fuel to do this,” wrote Aldrin.

With no atmosphere there were no familiar sounds from outside, no rustling leaves, no bird calls or human or animal noises, just the sound of their own breathing inside their helmets. A jet-black sky arced over the landing site… there wasn’t a cloud – there was nothing to relieve the intense blackness of the sky. The Eagle was safe on the lunar surface in an area ringed on one side by fairly good-sized craters, and on the other side by a boulder field, about the size of a house lot.

The first human voices on the moon crackled over the intercom and were relayed to the 600 million Earthlings holding their breath. As they all heard the first words from another world in English with an American accent, it seemed that for the first time in history the human inhabitants of the Planet Earth were globally united. Armstrong and Aldrin looked at each other through their visors, reached across and vigorously shook gloved hands, excited by the tension of the events on the way down.

Armstrong confessed, “If there was an emotional high point, it was the point after touchdown when Buzz and I shook hands without saying a word. That still in my mind is the high point.”

Aldrin’s thoughts were, “If there was any emotional reaction to the lunar landing it was so quickly suppressed that I have no recollection of it. We had so much to do, and so little time in which to do it, that no sooner had we landed than we were preparing to leave in the event of an emergency. I’m surprised, in retrospect, that we even took time to slap each other on the shoulders.”

A relieved Charlie Duke smiles at NASA cameraman Jerry Bray from his Capcom console moments after the touchdown. Astronauts Jim Lovell (Apollo 11 Backup Commander) and Fred Haise (Backup LM Pilot) are next to him.
Screen capture by Colin Mackellar from NASA 16mm footage.

Aldrin responded automatically to their training procedures and began to prepare for an emergency launch when he heard Armstrong announce:

> *"Engine arm is off… Houston, Tranquillity Base here. The Eagle has landed!"*
>
> Duke: *"Roger, Tranquillity. We copy you on the ground. You've got a bunch of guys about to turn blue. We're breathing again. Thanks a lot."*

With the Eagle safely down on the lunar surface, pandemonium broke out among the consoles in Mission Control. Cheering, backslapping, flag waving and handshaking engulfed the room as the flight controllers released their pent-up emotions for a few moments. In the back row Bob Gilruth clapped Chris Kraft on the shoulder and they shook hands. Neither could speak with the emotion of the moment.

Charlie Duke gratefully sank back into his chair, took a deep breath, and exchanged grins with Deke Slayton. He could hardly believe it had happened.

> Aldrin, *"Thank you."*
>
> Duke, *"You're looking good here."*
>
> Armstrong, *"Okay...* (To Aldrin) Let's get on with it. (To Houston) *Okay, we're going to be busy for a minute."*

"Okay everybody – T1, stand by for T1." Kranz rasped out to the flight controllers while Duke was still saying "We copy you on the ground", but then for a moment he was speechless. The 35-year-old crew-cut Kranz, who had the flight control team and himself under rigid control all the way down, admitted,

> "On the consoles for the TV tubes they've got two handles and I found myself with my left hand holding onto that handle like the console was going to run away and I kept scribing my notes and the paper kept rolling up on me because I'd be embedding notes that I was taking during descent, and when we finally got down on the surface the viewing room ... there were no people in there during training... they started cheering...that's when I finally found, my God, we'd landed!

Flight Director Gene Kranz gives Charlie Duke the "Stay for T1" call to pass to the crew.
Screen capture by Colin Mackellar from NASA 16mm footage.

When the viewing room erupted, I sorta froze and was speechless and just rapped my arm on the console and broke my pencil and bruised myself from my palm all the way up to my elbow."

The sudden pain was enough for him to regain control and coolly announce, "All right, everybody settle down, and let's get ready for a T+1 STAY/NO STAY."

At Honeysuckle Creek several of us left our Site Readiness Test, checking our equipment, to gather around the speaker in the Communications Room to hear the landing. I remember holding my breath for those last moments until we heard the Eagle was safely down. We had to know what to expect when the Moon rose above our horizon – with a safe landing it now looked as though we had a normal mission ahead of us.

Duke: *"...T1. Over. Eagle, you are Stay for T1."*

Armstrong: *"Roger, understand Stay for T1."*

T+1 was one minute after landing – decision time for staying or launching in a hurry if there was danger to the astronauts or spacecraft. There were only three minute or twelve-minute abort points – after twelve minutes they would have to wait for Collins in Columbia to go around the Moon again.

Just after Eagle had landed there was a moment of anxiety when engineers in Mission Control noticed the pressure rising dramatically in one of the descent engine fuel lines. The residual heat from the shutdown engine was creeping up to a slug of frozen fuel left in the pipe, with the consequence it might become unstable, explode like a small hand grenade, and cause damage to the ascent stage. Just when the engineers were about to hit the urgent action button, the pressure began dropping and the tension was over. Kranz, "We used a cryogenic bottle to pressurise our descent engine and we are wondering if this thing is going to explode."

Celebrations in Row 2 of the MOCR after touchdown. From right: Dick Brown, John Aaron (EECOM), Sy Liebergot (with pipe), Jack Kamman, Kathy Spencer, Buck Willoughby (GNC, writing).
Screen captures by Colin Mackellar from NASA 16mm footage.

From the other end of Row 2 after touchdown.
Bob Carlton (Control) is at centre closest to the camera.
Screen captures by Colin Mackellar from NASA 16mm footage.

Armstrong and Aldrin, however, did not consider it a serious problem.

Looking through his window, Aldrin tossed in a quick first impression:

"We'll get to the details of what's around here (later), but it looks like a collection of just about every variety of shape, angularity, granularity, about every variety of rock you could find. The colour is...well, it varies pretty much depending on how you're looking relative to the zero-phase point (the point on the horizon directly opposite the Sun). There doesn't appear to be too much of a general colour at all. However, it looks as though some of the rocks and boulders, of which there are quite a few in the near area... It looks as though they're going to have some interesting colours to them."

Collins in Columbia tried to follow events on the lunar surface

While Armstrong and Aldrin were in constant communication with Mission Control, Collins in the Command Module was spinning around the moon, relying on somebody relaying the events to tell him what was happening. After forty minutes of complete isolation behind the moon on each orbit, he could talk and listen to the Earth for seventy minutes through Goldstone and our Wing at Tidbinbilla, but he only had about eight minutes in touch with Eagle each time he passed over Tranquillity Base. Then it was back to another forty minutes of isolation. He happened to be in the contact zone when they landed, so heard the verbal exchanges of the landing.

Collins: *"And thanks for putting me on relay, Houston. I was missing all the action."*

From left to right: Milt Windler, Gene Kranz, Bill Tindall, Cliff Charlesworth.
Screen captures by Colin Mackellar from NASA 16mm footage

Duke: *"Roger. We'll enable MSFN (Manned Spaceflight Network) relay."*

Collins: *"I just got it, I think."*

Duke: *"Rog. Columbia this is Houston. Say something, they ought to be able to hear you. Over."*

Collins: *"Roger, Tranquillity Base. It sure sounded great from up here. You guys did a fantastic job."*

Armstrong: *"Thank you. Just keep that orbiting base ready for us up there now."*

Collins: *"Will do."*

Where had they landed?

But where had they landed? Nobody was sure. It wasn't that easy the mapping people were sweating now. Tracking data indicated the Eagle had landed 7.4 kilometres beyond the planned landing point, the error suspected to be caused by residual pressure in the connecting tunnel kicking the LM away from the CSM with more velocity than expected, and possibly mascons may have affected the LM's descent trajectory. Jerry Bostick, Flight Dynamics Officer in the Trench in Mission Control at the time, told me,

> "It's one of those things that is hard to definitively prove one way or the other, but my opinion is that it was a combination of the tunnel pressure and us not completely understanding (being able to accurately model) the mass concentrations."

Collins in Columbia was vainly scanning the lunarscape for signs of the LM each time he passed over, guided by Houston's latest update from the Mapping Sciences Laboratory in Houston. Using huge lunar maps and data from the spacecraft and tracking stations they narrowed it down to an 8 kilometres radius. Armstrong and Aldrin could not identify anything

of significance from their position. It wasn't until they were halfway home that their position was pinpointed by a chance remark by Armstrong.

Armstrong decides on an early EVA

The flight plan called for a four-hour rest period after landing. As everything had gone according to schedule, the LM was in good shape, and the astronauts weren't admitting to being tired, they were very keen to get out before their rest period.

At 104:39:14 GET (0811 AEST) Armstrong and Aldrin decided to postpone the four-hour scheduled sleep period and go out on the lunar surface straight away. Armstrong: "We wanted to do the EVA (lunar walk) as soon as possible. It would make more sense to go ahead and complete the EVA while we were still awake and not try to put that activity in the middle of a sleep period."

Armstrong*: "Our recommendation at this point is planning an EVA, with your concurrence, starting about 8 o'clock this evening, Houston time. That is about three hours from now."*

Duke: *"Stand by."*

Armstrong: *"Well, we will give you some time to think about it."*

Duke: *"Tranquillity Base, Houston. We thought about it. We will support it. We're go at that time. Over."*

Armstrong: *"Roger."*

Before 0900 AEST, Australian Prime Minister John Gorton visited the station. Here he speaks with Ed von Renouard at the Video Console. Photo: Hamish Lindsay.

More on Prime Minister Gorton's visit, including videos and photos.

Lloyd Bott (Deputy Secretary Department of Supply), Prime Minister John Gorton,
Allan Cooley (Secretary Department of Supply), Station Director Tom Reid
at Honeysuckle Creek on the morning of Monday 21 July 1969.
Photo by the Australian News and Information Bureau photographer.
Preserved by Hamish Lindsay. 2019 scan and image restoration: Colin Mackellar.
The photo was taken after the lunar landing, but before the EVA, and before the weather closed in.
Other photos here.

Mission Control and the tracking network get ready to support an early EVA

Goldstone would be tracking two-way with the LM on the Moon's surface when it came over our horizon. We began our Site Readiness Tests (SRT) checks at 0600 AEST and by 1042 AEST Honeysuckle Creek was ready for the day's events and went into the H-30 count, ready for an 1112 acquisition.

Lloyd Bott (Deputy Secretary Department of Supply), Prime Minister John Gorton, Allan Cooley (Secretary Department of Supply), Station Director Tom Reid at Honeysuckle Creek on the morning of Monday 21 July 1969.

Outside it was a freezing winter's day with sleet showers driving in from the west as the 26-metre antenna dropped down to the horizon and patiently waited. Inside the building the atmosphere thickened with tension as the day shift geared up for the first signs of a signal.

The Moon rose above the gum-tree clad mountains to the east beside Deadman's Hill and took a few minutes to come out of our eastern antenna keyhole at 1112 AEST. I wasn't sure that Deadman's Hill was a good point to acquire the LM – but we had no choice.

Honeysuckle Creek, Monday 21 July 1969

Hamish Lindsay, who took this photo, writes –

"This picture was taken of the HSK antenna tracking the Apollo 11 Lunar Module just before Armstrong took his first step onto the lunar surface.

Tom Reid, the Station Director, sent me out to record the moment. It was a wet and cold mid-winter morning – we were suffering sleet showers at the time, which you can see on the hills behind."

2018 scan by Colin Mackellar.

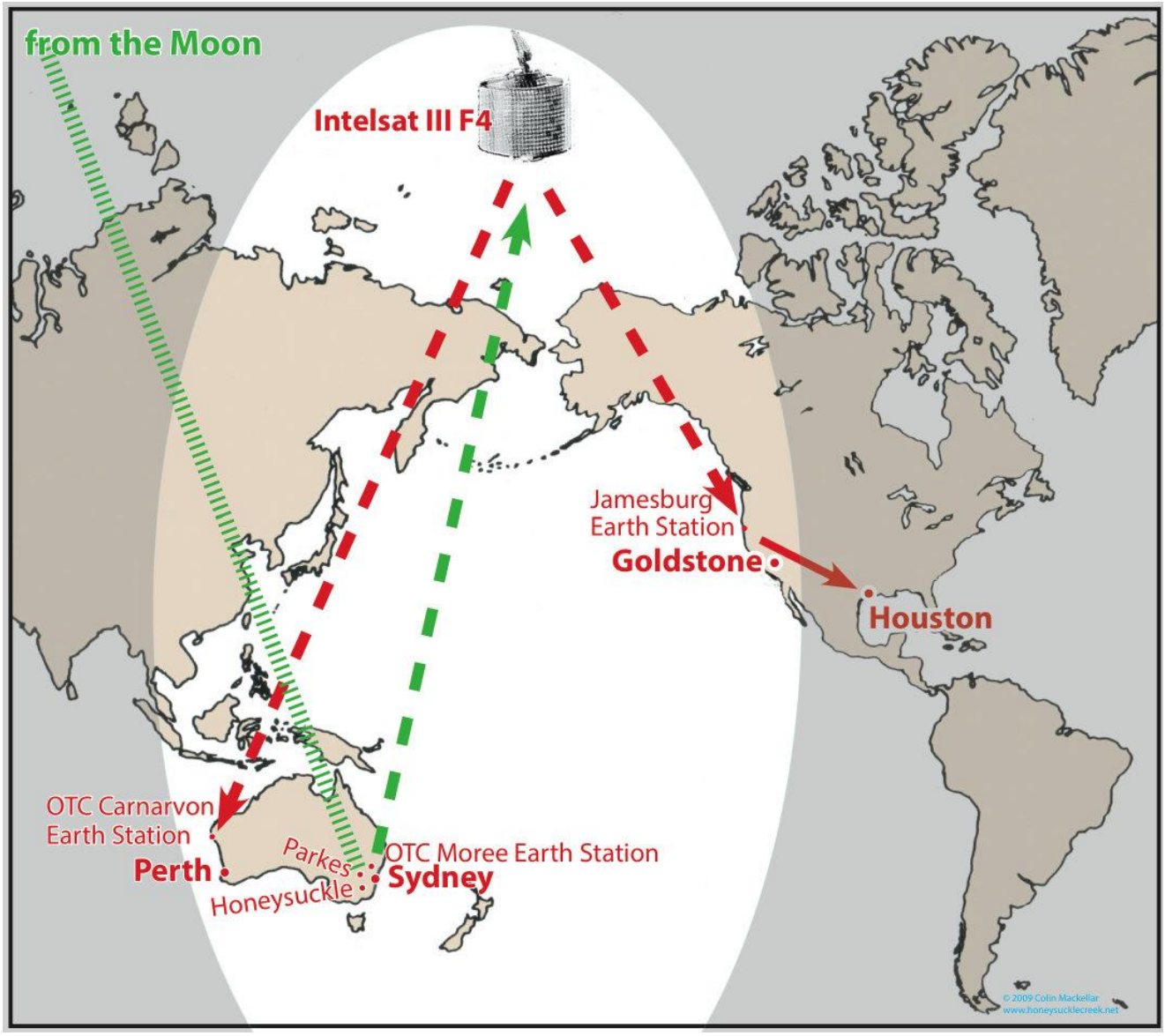
The Eagle's signal filled the station's receivers, and all the station equipment locked onto the data being sent from the receivers, while anxious eyes scanned all the readouts and reported good figures to the Operations Console. The operations areas were cleared for action as the astronauts prepared for the EVA. In contrast to Houston, there were no fast foods available in the Australian bush to be left about; we only had nice cafeteria food.

There was 1 hour and 44 minutes to Armstrong putting his boot on the lunar surface. Over at the Wing at Tidbinbilla they had just begun tracking Michael Collins in the CSM on his 17th Orbit.

Carnarvon and Western Australia improvise television links

At the time there was no television connection to the Australian eastern states. So, for this monumental occasion the Australian Broadcasting Corporation (ABC) planned to bring the moment to Western Australian viewers via the Carnarvon OTC Satellite Earth Station.

The signal would be transmitted in reverse along the new Perth/Carnarvon coaxial cable, which is everything along the cable route had to be reversed for the signal to flow from Carnarvon to Perth. Temporary equipment was installed at



TV from the Moon was relayed from Honeysuckle Creek and Parkes, via Sydney to the Moree Earth Station. From there it was transmitted to the Pacific Intelsat III F-4 satellite. Any Earth Station which could see the satellite (i.e. anything in the highlighted area) could receive the TV intended for Jamesburg and then Houston.

Larger version. More on this page.

Carnarvon. OTC, PMG and ABC staff working furiously away managed to have the links ready just one day before the step on the Moon. With the knowledge that they would actually see the first step on the Moon, moonwalk fever gripped Perth and TV rental companies were swamped with requests, schools prepared to suspend classes with TV sets made available, and shops set up monitors in their windows for crowds gathering outside to witness this historic moment.

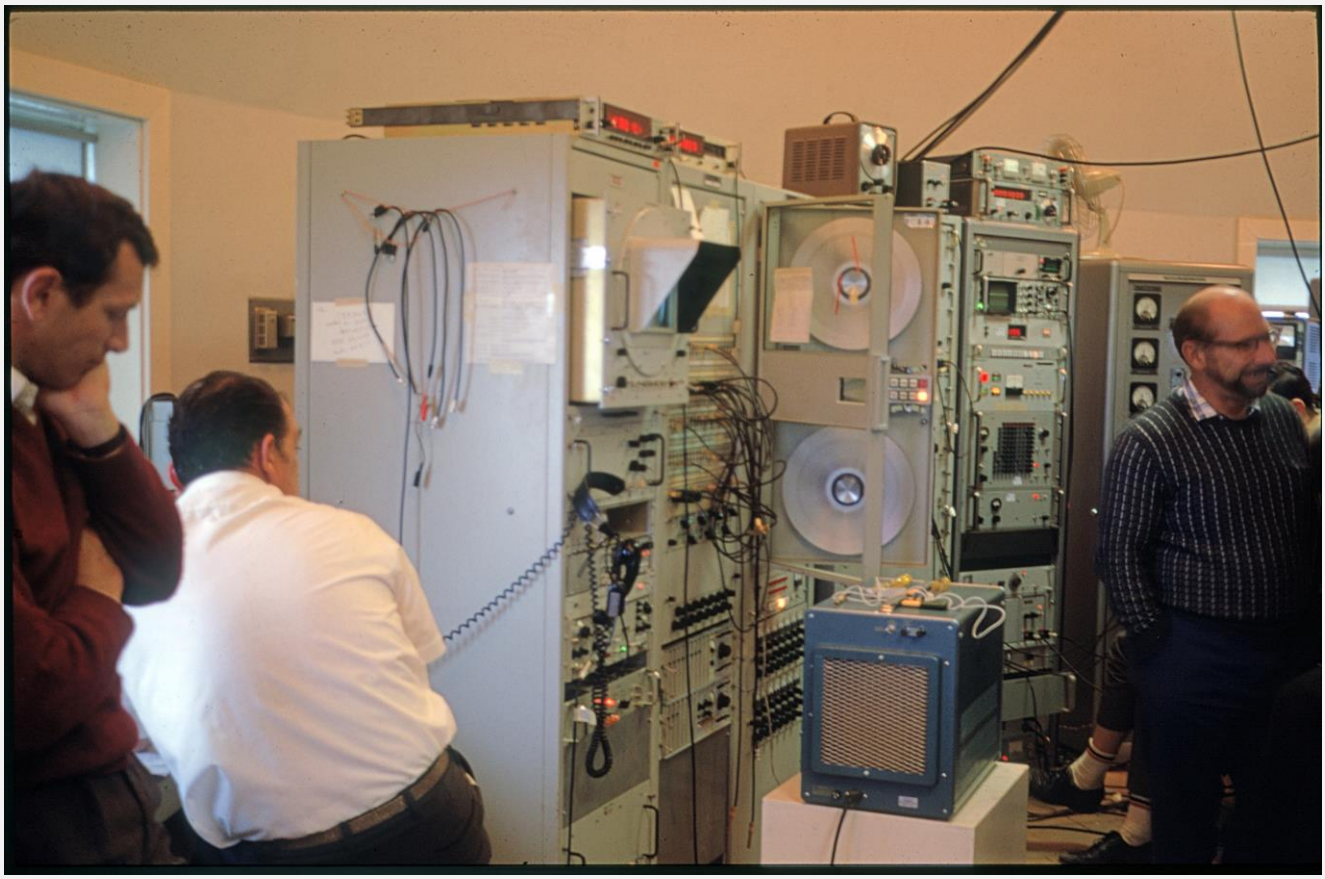
The original signal was transmitted from Honeysuckle Creek and Parkes to the Moree OTC station in New South Wales, up to the Intelsat III F4 satellite over the Pacific Ocean, and down to the Carnarvon OTC station.

Only one small television set was set up in the Carnarvon RSL theatre for local townsfolk to witness the event – for many, the first television they had ever seen.

Parkes suffers antenna-threatening gale force winds

Nearly an hour after Honeysuckle had acquired the signal, away over the paddocks, 250 kilometres to the north-northwest as the crow flies from Canberra, the CSIRO's famous 64 metre radio telescope at Parkes was wound down to its limits, waiting for the Moon to rise.

The Director, John Bolton, and Neil Mason were at the controls, and about 20 other operators were gathered in the control room and tearoom below, listening to the astronauts, trying to figure out when they were going to open the hatch and climb down to the surface.



David Cooke, Parkes Senior RF Engineer, took this photo of the control room at Parkes, showing the NASA equipment installed for Apollo 11.

The Slow Scan TV monitor is closest to the camera. Modified VR-660 video recorders are just out of view behind Honeysuckle's John Crowe at left.

With his back to the camera is NASA team leader Robert Taylor (Goddard Space Flight Center), and NASA USB engineer George Kropp (normally based at MILA) is at right.

With thanks to David Cooke. 2018 slide scan by Colin Mackellar.

Parkes Telescope Driver Neil "Fox" Mason at the Parkes Radio Telescope, 20th July 2014.
Photo: Colin Mackellar.

Neil Mason:

"My role at the time was to just point the dish at a certain point on the Moon and I had a voltmeter on top of desk in front of me so I could see the strength of the signal we were getting. We were there sitting around waiting for the Moon to rise above the horizon. We could see it in the sky at that stage, but the telescope couldn't see it.

In the control room at the time, it wasn't like the movie The Dish, where they only had four people there – there were probably twenty-odd people around all doing different jobs.

The next thing a gust of wind hit us, alarm bells sounded, and everyone's going, "What the hell's that?" you know. You're sitting there with a 1,200-tonne dish rolling around the top of your head and there's creaks and bangs. The motors are trying to drive the dish down – the wind is pushing it back, and you sort of get a bit nervous. Rumbles were going on.

If we obeyed the rules, we would just break off the track, stow the dish, and put it up on jacks. We looked at each other and said, 'What do we do now?' 'What's going to happen?'

The astronauts were just about to open the hatch, so we ignored the wind restrictions and waited for the moon to rise. I was relieved when the boss said to keep going, as it took the decision off my shoulders."

The big question was, would the Moon be in their main feed when they did exit the LM? It looked as though it was going to be a race.

Powerful gusts of wind stirring thick dust clouds could be seen to the south, racing towards their vulnerable antenna. Unable to do anything at this late stage they winced as 112 kilometre an hour gusts (well over the specified safety limit of 48 kilometres per hour) attacked the big dish, slamming it against the zenith angle drive pinions. The Director, John Bolton, checked the strain gauges on the walls and said, "This is only going to happen once…" and decided to keep tracking and take the chance the structure would survive.

Luckily, the winds eased a bit before Armstrong climbed out and Parkes was able to provide one of history's greatest telecasts, despite the winds continuing to batter the antenna beyond its safety limits.

Using a less sensitive 'off-axis' detector, Parkes was able to receive the television pictures just as the LM's camera was switched on, but because they would have a lower quality picture and could expect a break in their data switching to the main feed, were not selected to be broadcast to the networks until the LM's signal reached the main beam.

In Mission Control there were two teams of controllers, one led by Clifford Charlesworth to run the EVA, and one led by Milton Windler to run the sleep period. These two teams now had to stand by while the EVA decision was under way. Charlesworth nicknamed 'the Mississippi Gambler' by his peers because of his apparent laid back attitude, won the next shift when the decision to go for a walk first came down the line. He took over from Kranz and settled in with his controllers to support the EVA. A poll confirmed everyone was GO.

Mission Control was ready for the history making EVA.

David Cooke took this photo at Parkes, after the windstorm had died down, around 5:00pm, just before sunset.
With thanks to David Cooke for the loan of his transparencies.
2018 scan and (quite a bit of) image repair by Colin Mackellar.

Honeysuckle Creek prepared for action

John Saxon, Operations Supervisor at Honeysuckle:

> "The checks on the portable life support systems at this point were in a totally different sequence to what we were expecting every time they changed modes, we had to make major reconfigurations on the ground we were really, really busy trying to keep up with the astronauts doing their own thing.
>
> The busiest man without question, was Kevin Gallegos, the man at the front end at the Sub Carrier Demodulation equipment because all these modes affected how he routed the signals through the station and he had to literally second guess what the astronauts were doing, because they were not following the planned sequence. He was calling out all the things he was seeing, we were then directing the telemetry people who were actually, processing the support data such as the astronauts heart beats, trying to report to Houston what was happening all the time, telling them what we were doing, and keeping a log of all the events. It was a real team effort."

Kevin Gallegos, who was working on the Data Demodulators (SDDS) using an oscilloscope to watch the images (in phosphor green) remembered:

> "I broke out in a cold sweat because they were saying things should be happening, the Saxons of the world were saying it had happened, the telemetry bloke was looking around saying 'where is it?' and I looked up and found to my horror that I wasn't patched right. It was one of those things you have gone over that many times in your head I just looked at it in utter disbelief, so I quickly whipped it around, and in the euphoria of the moment everything took off. There's ten seconds of my life there where I can still feel that cold sweat thirty-five years later!"

Kevin Gallegos at SDDS (the Signal Data Demodulation System) just after the conclusion of the EVA on Monday July 21, 1969.

From the Super 8 movie by Ed von Renouard.

The astronauts get ready for their EVA

On the Moon, Armstrong and Aldrin were slowly hurrying into their EVA suits in the cramped space of the LM's cabin, surrounded by vulnerable switches and instrument panels. The preparation time was expected to take about two hours, but nobody was surprised when it took 3½ hours. Every move had to be meticulously carried out and checked. A lot of the drill took longer than planned because they never had a chance to simulate all of it under the right conditions – such as clearing away the remnants of their last meal.

Armstrong took a look out the window to see the conditions outside and commented,

"I still find that the area around the ladder is in a complete dark shadow, so we're going to have some problem with the TV…but I am sure you will see – you'll get a picture from the lighted part."

Audio

The First Step – 19 min 56 sec / 4.6MB –

Starting at 12:53:18pm on Monday 21st July 1969 (AEST).

Recorded by Bernard Scrivener at Honeysuckle Creek – Net 1 audio from Goldstone. Digitised by Mike Dinn.

Opening the LM's hatch

By the time Honeysuckle Creek had locked on to the LM's signal at 1112 AEST the astronauts were nearly ready to open the hatch. At 1239 AEST, 1 hour and 27 minutes after we had acquired the LM's signal, Aldrin reached for the handle to open the hatch.

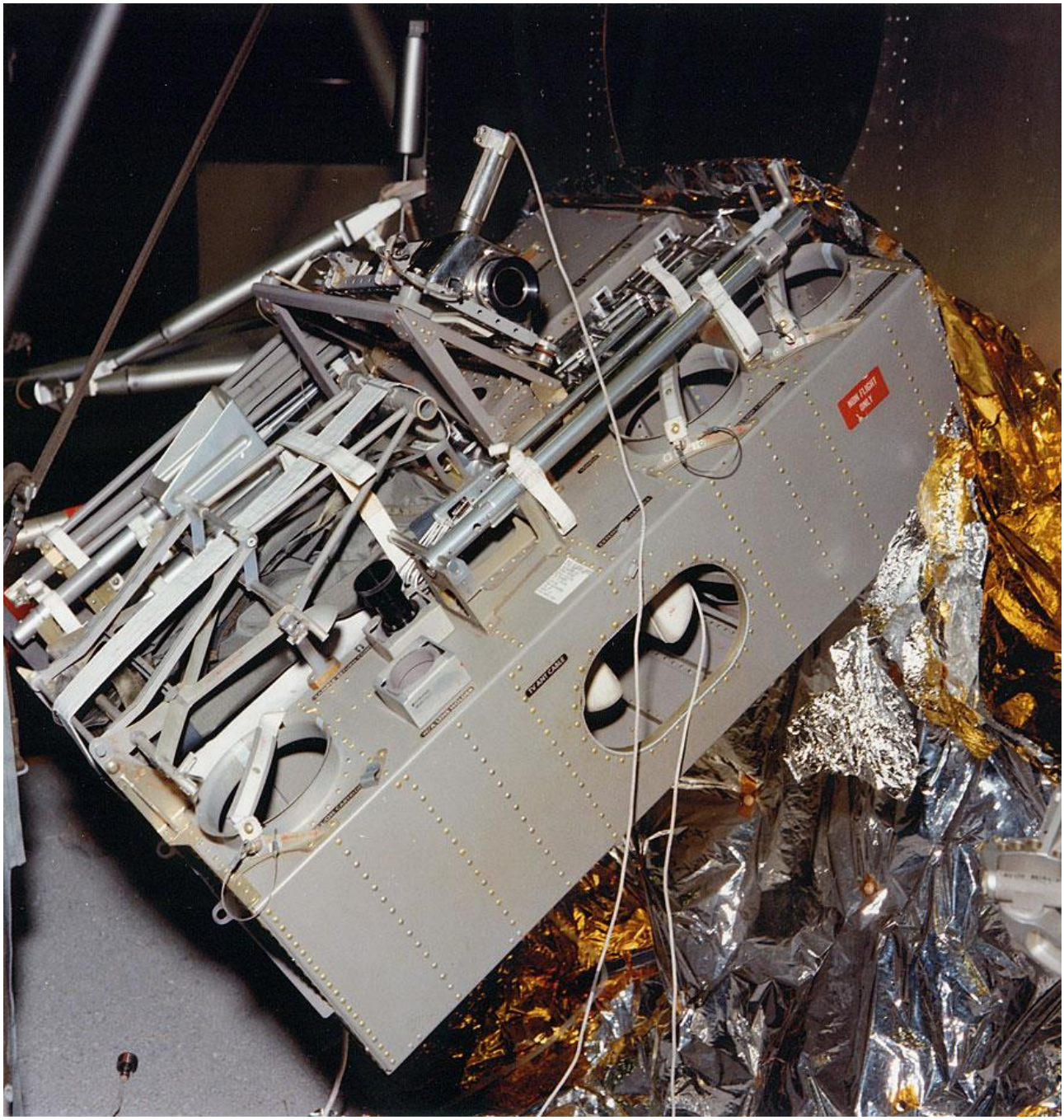
Armstrong: *"Everything is go here. We're just waiting for the cabin pressure to bleed, to blow enough pressure to open the hatch."*

McCandless: *"Roger, we're showing a relatively low static pressure in your cabin. Do you think you can open the hatch at this pressure of about 0.1 psi?"*

Armstrong: *"We're going to try it…"*

The hatch stayed stubbornly shut as there was still some pressure remaining in the LM's cabin. Aldrin tried peeling a corner of the hatch seal back and that released the pressure to allow the hatch to open.

"The hatch is coming open," said Armstrong as he watched a little flurry of ice particles burst through the widening slot.



A mock-up of the MESA with the camera mounted upside down.
NASA image S69-31584.

With the hatch open he eased himself though the opening, careful to guide the bulky EMU backpack and its antennas through the hatch without snagging anything.

Armstrong was so engrossed in working his way through the hatch, Aldrin had to remind him to open the MESA (Modular Equipment Stowage Assembly).

Aldrin: *"Did you get the MESA out?"*

Armstrong reached out to yank the D ring and lanyard as Aldrin closed the television circuit breaker:

"I'm going to pull it now …… Houston, the MESA came down all right."

McCandless: "This is Houston. Roger, we copy, and we're standing by for your TV."

Armstrong: "Houston, this is Neil. Radio check?"

Armstrong found that what they had learned during their simulations in the water tank and airplane, such as body positioning, when to arch the back, keeping clear of snags and helping each other, were very close to the real thing. As he was a communication relay station for Aldrin still inside, both astronauts were following their checklists, which called for confirmation they had radio contact through the external EVA antenna. Houston also reminded Aldrin to turn the TV Camera on. He was now outside the LM.

McCandless: "Neil, this is Houston. You're loud and clear. Break. Break. Buzz, this is Houston. Radio check and verify TV circuit breaker in."

Aldrin: "Roger. TV circuit breakers in – and read you loud and clear."

McCandless: "Roger…… And we're getting a picture on the TV."

Aldrin: "You got a good picture, huh?"

McCandless: "There's a great deal of contrast in it, and currently its upside down on our monitor, but we can make out a fair amount of detail."

This is the scene in the MOCR (Mission Control), moments before the television camera is turned on. The image on the large back-projection screen shows the test bars being sent from Goldstone.

Armstrong was surprised to hear Houston had a picture, not expecting the system to work so quickly, in fact later he admitted he was very surprised it had worked at all as it had never worked during simulations.

At Honeysuckle Creek, television technician Ed von Renouard was watching his screen intently for the first signs of a picture. He heard Aldrin say the circuit breaker was in and suddenly, at 109:22:00 GET (1254 AEST), an image appeared. There was a flurry of energetic activity as the television operators tried to decipher the strange fuzzy shapes on their screens.

This was the conversation on the interstation communication channel as the operators stared at the historic images on the screens before them.

Goldstone: "TV online, Goldstone TV on line."

Honeysuckle: "Honeysuckle video online."

Houston TV: "Houston TV, we have both sites five by."

Houston TV: "Goldstone… can you confirm that your reverse switch is in the proper position for the camera being upside down?"

Goldstone: "Stand by, we will go to reverse position. We are in reverse."

Houston TV: "Roger, thank you."

Houston TV: "All stations, we have just switched video to Honeysuckle."

Audio

Net 2 audio – 2 min 14 sec / 1MB.

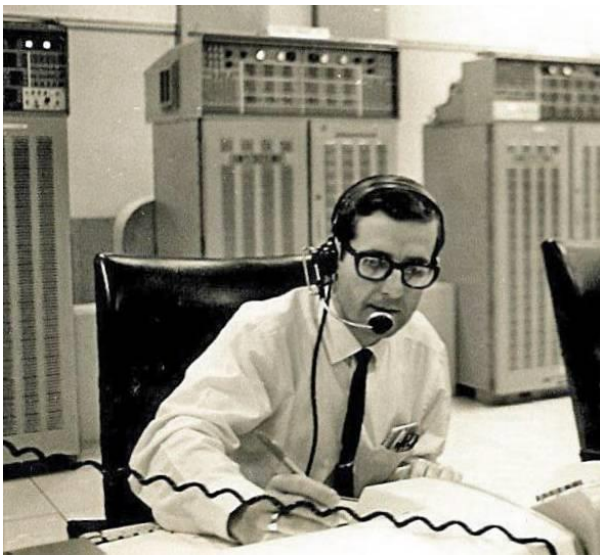
Hear the above exchange as the TV comes on.

Full audio and details here.

Digitised by Mike Dinn.

Bryan Sullivan, Technical Officer in the computer area remembers:

"I arrived on shift, sat down at the computer console with the rest of the team, and pulled on my headset. The previous shift was still in the middle of the five-hour SRT that had begun several hours ago. The Telemetry section was running simulated mission data from the analogue tape recorders through the



telemetry decommutators. Les Hughes was selecting the different decom. formats corresponding to requests from CADFISS TM. I took over from Don Loughhead monitoring of the various data formats being transmitted to the Real Time Computers via Goddard Data Link.

Quietly and smoothly the night shift unplugged their headsets and withdrew from the activity as a fresh team got up to speed. Eventually all was calm, as we listened to the astronauts chatting away on Net 1.

We just watched and listened, except for the periodic computer keyboard entries and magnetic tape changes. Both the Command and Telemetry computer software were functioning perfectly.

By midday people began to file into the operations areas, secretaries, store men, clerks, maintenance men. When I looked around they were all standing like statues silently behind me. Even Bill Shaw the station gardener had abandoned his ride-on mower. Everyone stood well back, though, as we scanned the rows of blinking lights on the computers and peripheral equipment with one eye and with our other eye on the flickering CCTV monitors, waiting for the first sign of a picture from the Moon.

Suddenly the flickering blank greyness on the monitor gave way to a fuzzy black and white scene of a ladder upside down. A few seconds later 'Video Von' (Ed von Renouard) flicked the switch to invert the image. I managed to stretch my headset cable far enough to look

over Ed's shoulder and see the Slow Scan monitor and know that I was viewing the historic scene microseconds ahead of the rest of the world's media."

Goldstone tracking station suffers television picture problems

The first television frames used were sent by the big 64-metre Mars antenna at the Goldstone Tracking Station in California, but they were in trouble as Bill Wood, USB Lead Engineer at Goldstone explains:

"I saw the network TV here – we were picking up the commercial television out of Los Angeles and when we saw the switch from Goldstone to Honeysuckle there was a pronounced improvement in the video quality. 'Hey, look at the picture from Honeysuckle!' and I thought 'Good Lord there's something wrong with our system – they are getting it much better than we are."

[Editor's note: The scan convertor operator at Goldstone was having trouble with the settings on his Scan Converter. While Goldstone was receiving an excellent picture from the Moon, the equipment to convert it to US television standards was set too dark with all the greyscale detail being lost. Armstrong could barely be seen.

The picture was also slightly out of focus. In addition, initially it was upside-down. A switch to invert the picture, due to the camera being mounted upside-down in the MESA was in the wrong position. While attempting improve the picture, its polarity was inverted, making it look like a photographic negative.

Given time, the scan-converter settings could have been corrected at Goldstone, but Armstrong was on the surface only two minutes and twenty seconds after the camera was turned on. Houston TV had switched to the Australian feed some 37 seconds before the First Step and stayed with the Australian source for most of the EVA.]

This comparison shows that the scan-converted picture coming from Goldstone (top) was very dark, even though the signal was received on their 210-foot (64 metre) dish.

The same frame of TV, received via Honeysuckle's smaller 85-foot (26 metre) dish, and scan-converted at the station, shows much more detail.

See the 'Parkes and Honeysuckle' page in the Apollo 11 TV section for more.

Honeysuckle Creek saves the day

Honeysuckle's video tech Ed von Renouard at the scan converter.

The slow scan TV picture from Apollo 11 was displayed on the monitor at the top left. The switch to invert the image is the small toggle switch directly above his head.

Scan by Hamish Lindsay, photo taken during Apollo 12. Large, Larger.

Ed von Renouard, the television technician at Honeysuckle Creek:

> "When I was sitting there in front of the scan converter, waiting for a pattern on the input monitor, I was hardly aware of the rest of the world. I heard Buzz Aldrin say, 'TV circuit breaker in' and at the same moment I saw the sloping strut of the Lunar Module's leg against the moon's surface. The input monitor receiving the slow scan from the spacecraft showed the scene upside down, but this was expected and planned for, and our signal went to Sydney right way up. A few weeks before the mission someone at NASA discovered that when the MESA hatch with the TV camera attached was opened the camera would be upside down, so a switch was installed at the tracking stations to invert the picture."

Tom Reid, Honeysuckle Creek Station Director:

> "There were four contingencies which resulted in Honeysuckle Creek being the station which sent the picture of Neil Armstrong's footstep around the world.
>
> First of all, the original Flight Plan called for the egress to occur when the Goldstone and Parkes' 64-metre antennas were in view, so there would be a 100 percent redundancy in

Honeysuckle's video tech Ed von Renouard at the scan converter.

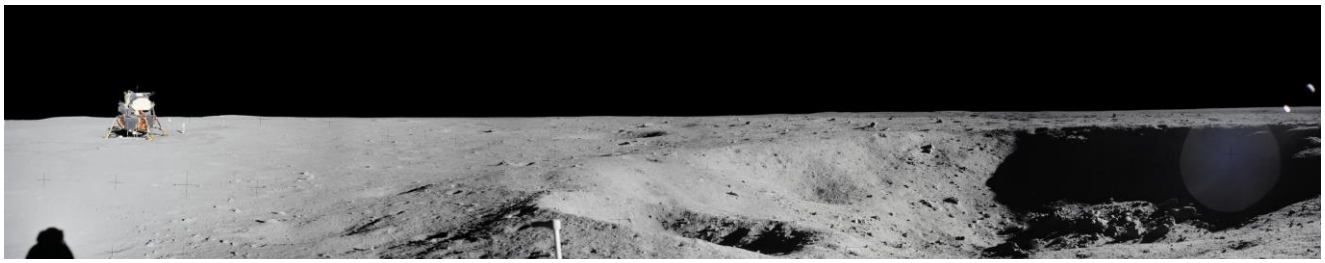
The slow scan TV picture from Apollo 11 was displayed on the monitor at the top left. The switch to invert the image is the small toggle switch directly above his head.

Scan by Hamish Lindsay, photo taken during Apollo 12. Larger version

64-metre antennas. Armstrong, however decided to come out early, and the Mission Controllers decided that they wouldn't oppose that decision.

Because of that, when they actually did come out, Parkes didn't have a view because they had an elevation constraint, only able to come down to 29° 38' above the horizon (the Moon wasn't high enough for the Lunar Module's signals to enter their main beam).

Unfortunately, at the same time there was a problem at Goldstone, and they were sending a poor-quality slow scan upside-down TV picture back. Due to the transmitter failure earlier at Tidbinbilla, Honeysuckle Creek was tracking the Lunar Module."



This video recording of the feed from Honeysuckle Creek to the Sydney Video switching centre was preserved by Kipp Teague and identified by Colin Mackellar in 2006. The tape is damaged at the start.

This second or third generation copy is the only known recording of the Honeysuckle picture from the start. It begins just as Bruce McCandless calls, "We're getting a picture on the TV!"

It's available here as a 20MB MPEG4 video file – click on the picture to open the file in a new window, or right click to download.

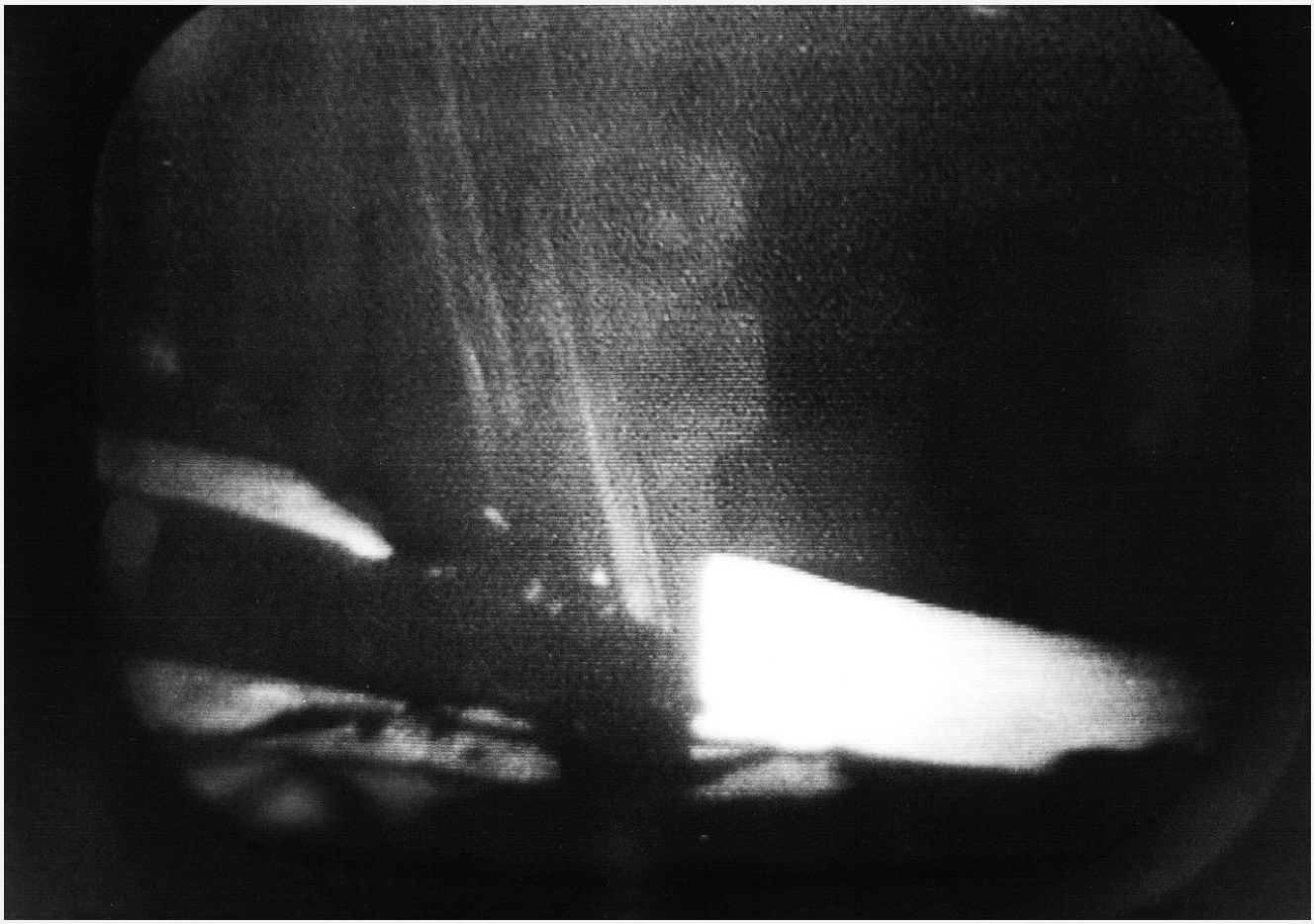
THAT FIRST STEP ON THE MOON'S SURFACE

McCandless: *"Okay, Neil, we can see you coming down the ladder now."*

With troubles at Goldstone, and Parkes yet to receive a main beam signal, Houston video switched to the Honeysuckle Creek video signal being sent to them by Sydney Video, though they left the sound from Goldstone, and viewers around the world were able to make out the ghostly looking scene of the black sky and white lunar surface with Armstrong's legs carefully seeking each rung of the LM's ladder.

Unaware of the television picture dramas back on Earth, Armstrong worked his way to the bottom of the ladder and looked down. The impact of landing should have compressed the LM's legs and only given him a reasonable step down, but his landing had been so gentle he still had a metre to jump down from the bottom rung.

He jumped for the LM's dish-shaped footpad and, to check he could still get back on the ladder, immediately jumped back up. With the Moon's weaker gravity, it was no problem. Armstrong returned to the footpad and looked down at the lunar surface.



Neil Armstrong descends the ladder. GET 109:22:40
Photo taken from the video console at Honeysuckle Creek.
Others here.

> "I'm at the foot of the ladder. The LM footpads are only depressed in the surface about two inches
>
> (5-centimetres), although the surface appears to be very, very fine grained as you get close to it; It's almost like a powder.
>
> The groundmass is very fine…… Okay I'm going to step off the LM now."

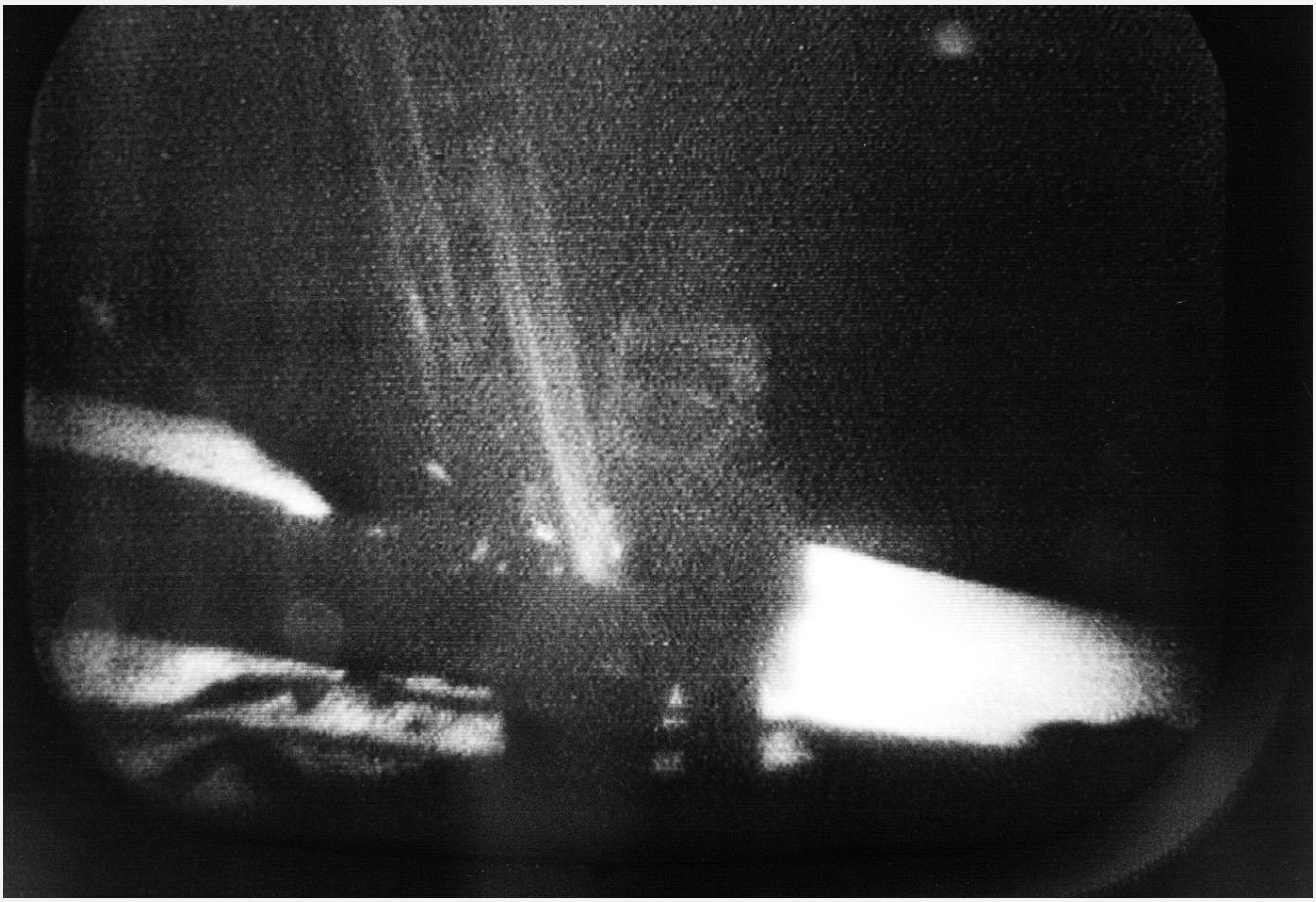
Carefully he raised his left boot and planted it onto the soil, checking it would take his weight.

At 109:24:15 GET, 2156:15 USCDT (late evening spacecraft time), July 20 (1256:15 AEST July 21, 1969) 38-year-old Neil Alden Armstrong from Wapakoneta, Ohio, USA, stepped onto the lunar surface and spoke those immortal words:

"That's one small step for (a) man…one giant leap for mankind."

A breathless world glued to every television and radio set available on the planet, was mesmerised by the moment. Buzz Aldrin was watching through the hatch.

Still holding on to the LM, Armstrong dragged his boot across the soil, making furrows. The dusty lunar soil clung to his boot like a fine black powder. Now confident, he let go of the LM and tried walking around. He felt quite buoyant, his 163-kilogram weight with the spacesuit on Earth now only 27 kilograms.



Neil Armstrong on the footpad, about to step onto the surface.
GET 109:24:39. Photo taken at the video console at Honeysuckle Creek.
Click here for more TV images from HSK.

Armstrong: "The surface is fine and powdery. I can kick it up loosely with my toe. It does adhere in fine layers, like powdered charcoal, to the sole and sides of my boots. I only go in a small fraction of an inch, maybe one eighth of an inch, but I can see the footprints of my boots and the treads in the fine, sandy particles."

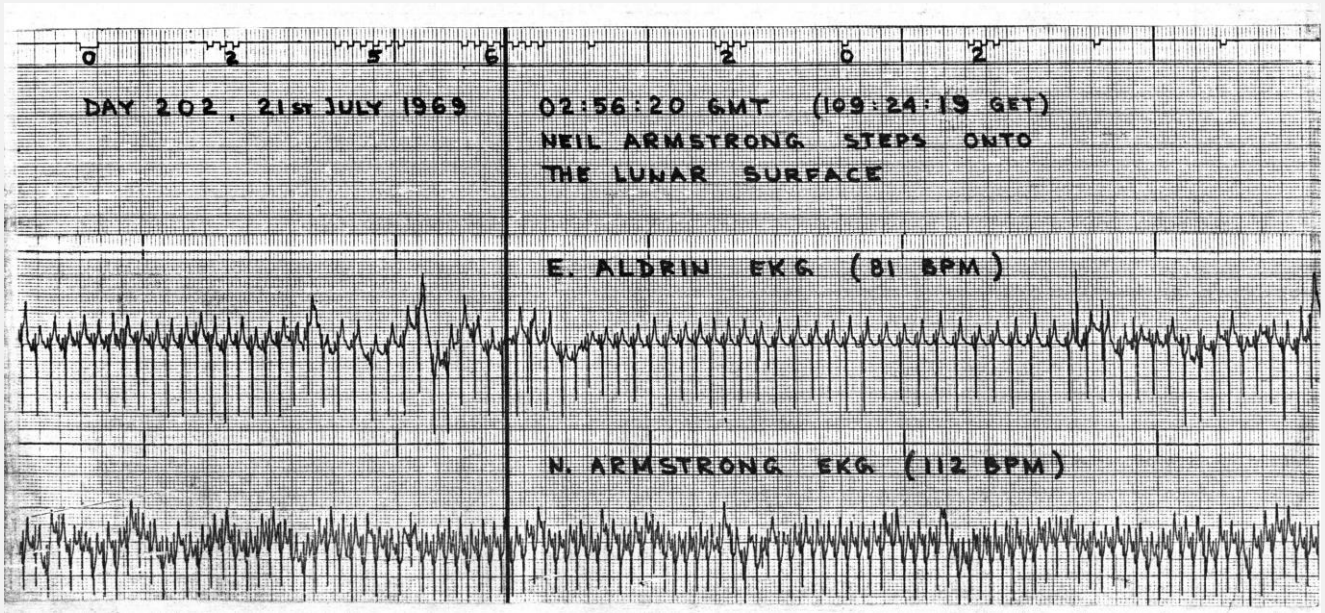
McCandless: *"Neil, this is Houston, we're copying."*

Then after a pause, Armstrong: *"There seems to be no difficulty in moving around, as we suspected. It's even perhaps easier than the simulations of one sixth g that we performed in the various simulations on the ground. It's absolutely no trouble to walk around."*

One of the first tasks was to get a contingency sample of lunar soil, but Armstrong was so anxious to get the Hasselblad camera and take pictures that he had to be reminded a couple of times to scoop up some samples. Back in mission control, the scientists were nervous that a sudden unexpected life-threatening crisis might send Armstrong scuttling back into the LM and it seemed ridiculous to go all that way and not bring back some lunar samples for scientific analysis, but Armstrong felt that a quick sequence of panoramic pictures before picking up the samples was the way to go.

Collins in Columbia misses the moment

At this point Columbia was out of sight behind the moon. Collins had been trying to locate the LM from orbit (he never did), but he desperately wanted to hear what Armstrong was going to say when he stepped on the Moon, and he realised he was the only person out of contact with the epoch-making events. All the billions of people around Earth with his two mates on the other side of the moon, and he was the only person completely cut off from it all! Complete silence except for the spacecraft noises. Columbia did not reappear until Armstrong and Aldrin were raising the flag, so Collins missed hearing Armstrong's momentous step onto the lunar surface.



These EKGs of Armstrong's and Aldrin's heart rates at the time of the first step were recorded at Honeysuckle Creek. Station Director Tom Reid sent a copy to Parkes, and Mike Linney made copies for Honeysuckle staff. Larger version.
This copy preserved by Bryan Sullivan, Scan by Colin Mackellar.

Armstrong announced, *"Looking up at the LM, I'm standing directly in the shadow now looking up at Buzz in the window. I can see everything quite clearly. The light is sufficiently bright, back lighted into the front of the LM, that everything is clearly visible."*

After some discussion on cameras Armstrong said, *"I'll step out and take some of my first pictures here."*

McCandless, "Rog, Neil, we're reading you loud and clear. We see you getting some pictures and the contingency sample."

Armstrong had planned the first still picture would be his first boot print in the lunar surface but to his dismay when he came to take the picture, he found he had already trodden all over the imprint, obliterating all traces of it.

After taking the first photographs, Armstrong moved into the sunlight and began collecting the first contingency soil samples. Using a long-handled scooper to dig into the surface, he found the topsoil was quite loose, but became hard and cohesive about 17 centimetres under the surface. He added a couple of small rocks and dropped the samples into a strap-on pocket on his right thigh.

Parkes locks on to Eagle's signal

Eight minutes and fifty-one seconds after the television was switched on, the CSIRO's 64 metre antenna at Parkes came online at 1306 AEST when the LM on the moon rose high enough above the horizon for its signal to enter the main feed of the big dish providing a 12db increase in signal strength over the Honeysuckle signal.

Neil Mason hunched over his controls, concentrating on following the LM's signals while around him he could still hear alarm bells mixed with creaks and thumps as the motors tried to hold the antenna against the onslaught of the wind tearing at the dish. Director Bolton gave the order to keep going.

When a clear picture appeared on their screens from the main feed at Parkes, Sydney Video switched the Parkes signal through to Houston who fed it to the waiting world. Parkes' signal was used for the rest of the two-and-a-half-hour broadcast.

Sydney Video advised Houston TV:

Sydney Video: "Houston TV, Sydney Video."

Houston TV: "Houston TV, Go ahead."

From left: Charlie Goodman, Verne McGlynn, Richard Holl (standing at the Fairchild slow scan monitor), Elmer Fredd (seated at the scan-converter), Ted Knotts, and Ray Louve (seated at the Ampex VR-660).

Photo: With thanks to Dick Holl for the scan of this Department of Supply photo.

Credit: Still Photography Section, W.R.E. Salisbury, S.A., NEG. No. CN69/115, 1969. Image restoration Colin Mackellar.

More on Sydney Video in the Apollo 11 TV section.

Audio

Net 2 audio – 1 min 06 sec / 570kb.

Hear the above exchange as Charlie Goodman (Sydney Video) reports to Ed Tarkington (Houston TV) he is getting a very good picture from Parkes.

First voices heard: HSK StaDir Tom Reid calls Kevin Gallegos (HSK SDDS). Full audio and details here. Digitised by Mike Dinn.

Sydney Video: "Please be advised I have a very good picture from Parkes, shall I give it to you?"

Houston TV : "Roger"

Sydney Video: "You have it."

Houston TV: "Roger, beautiful picture, thank you."

Houston TV: "We are switching to Parkes at this time."

Network: "Honeysuckle, Network."

Armstrong steps into the Sun as he waits for Aldrin to descend the ladder. Picture through Parkes.

Station Director Tom Reid: "Network, Honeysuckle."

Network: "You might pass on to the Parkes people – their labour was not in vain; they've given us the best TV yet."

Reid: "Roger, thank you very much, they'll appreciate that – they're monitoring."

Within 16 minutes of Armstrong's step onto the lunar surface Aldrin began backing cautiously out of the Lunar Module's hatch.

Aldrin: "Okay, Now I want to back up and partially close the hatch…… making sure not to lock it on my way out!"

Audio

Net 2 audio – 28 sec / 328kb.

Houston Network Controller Ernie Randall asks HSK Station Director Tom Reid to pass a message on to Parkes. Full audio and details here. Digitised by Mike Dinn.

Armstrong chuckled: "A particularly good thought."

Aldrin: "That's our home for the next couple of hours, we want to take good care of it."

Aldrin worked his way down the ladder and jumped onto the LM's footpad. He also tried to leap back onto the ladder, but missed the bottom rung by about two centimetres, so tried again –

Armstrong: "There you've got it."

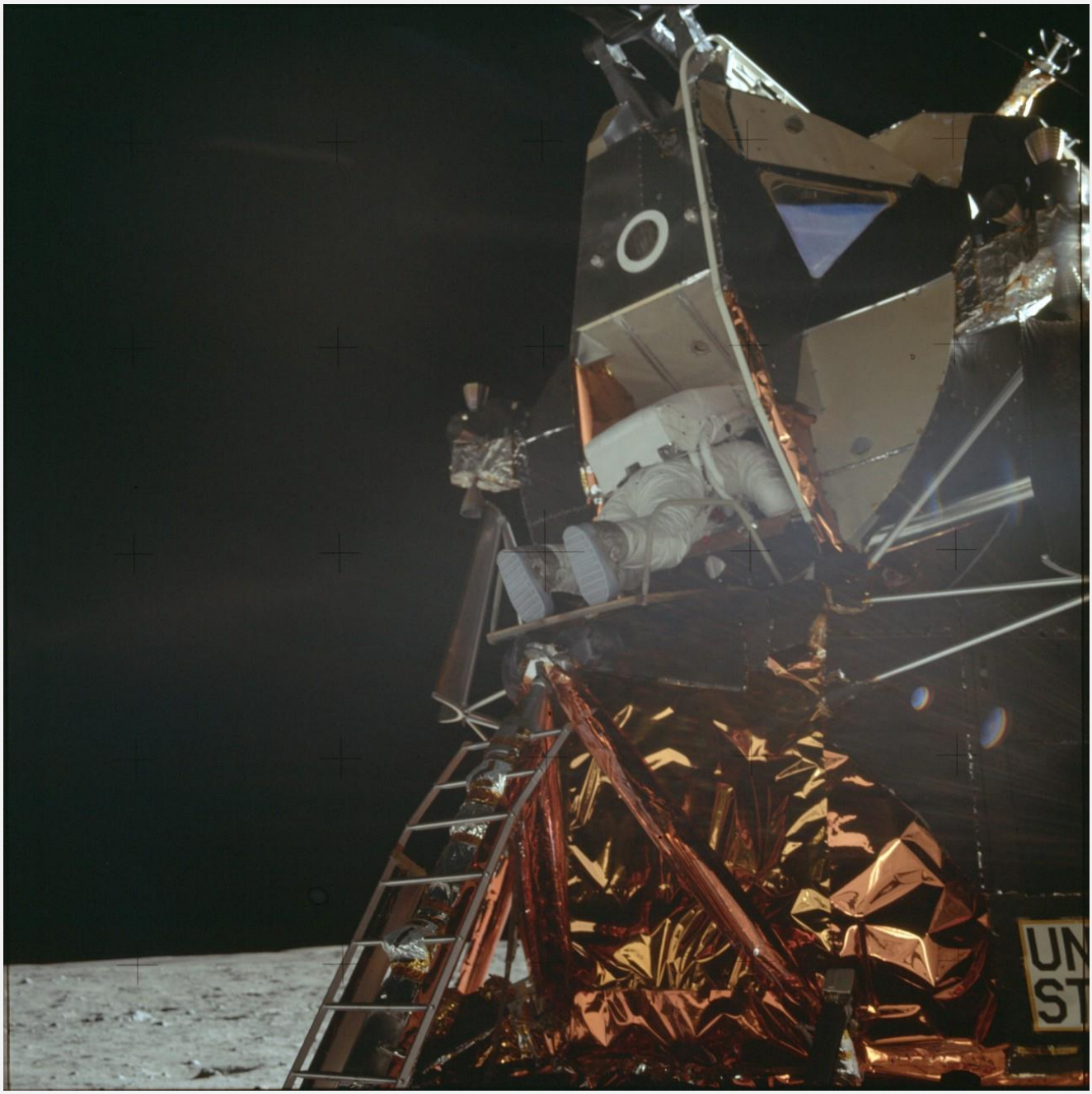
Aldrin: "That's a good last step……!"

Armstrong: "Yeah, about a three-footer."

Aldrin: "Beautiful view!"

"Isn't that something? Magnificent sight out here," Armstrong greeted 39-year-old Edwin Eugene "Buzz" Aldrin from Montclair, New Jersey, as he joined him to become the second man to step onto the lunar surface.

"Magnificent desolation," returned Aldrin, searching for an appropriate remark, was inspired by Armstrong's comment.



Buzz backing out of the hatch of the LM.

NASA image AS11-40-5863. Johnson Space Center.

FIRST WALK IN ANOTHER WORLD

Aldrin,

> "Stepping out of the Lunar Module's shadow was a shock. One moment I was in total darkness, the next in the sun's hot floodlight. I stuck my hand out past the shadow's edge into the sun, and it was like punching through a barrier into another dimension."

Both astronauts found their suits comfortable to walk around in, except when bending down to pick an object up, when they had difficulty getting back up. There were no noticeable warm spots or differences in temperature between shadow and sunlight. The suits were designed to cope with the extreme conditions expected in the lunar environment, isolating the astronauts from the vacuum outside and the wildly fluctuating temperatures. The temperature of the ground they were walking on could vary from 110°C in sunlight to -170°C in the shade.

As Armstrong didn't wear his inner gloves, he found his hands were warm and very wet all

the time, which made it more difficult to handle objects and get a firm grip on things. He tried some high jumps but found once he came close to falling over backwards decided, "… that was enough of that."

Armstrong,

"From inside the cockpit the moon looked warm and inviting. The sky was black, but it looked like daylight out on the surface, and the surface looked tan. There is a very peculiar lighting effect on the lunar surface, which seems to make the colours change. If you look down sun, down along your own shadow, or into the sun, the moon is tan. If you look cross-sun it is darker, and if you look straight down at the surface, particularly in the shadows, it looks very, very dark. When you pick up material in your hands it is also dark, grey or black.

The material is of a generally fine texture, almost like flour, but some coarser particles are like sand. Then there are, of course, scattered rocks and rock chips of all sizes."

The portable life support system (PLSS) on their backs had weighed 38 kilograms on Earth, but on the Moon, they were a mere 6.3 kilograms.

Aldrin:

"I felt buoyant and was full of goose pimples, I quickly discovered that I felt balanced comfortably upright only when I was tilted slightly forward. I also felt a bit disorientated – on the Earth when one looks at the horizon, it appears flat; on the moon, so much smaller than the Earth and quite without high terrain, the horizon in all directions visibly curved away from us."

Armstrong,

"After landing we felt very comfortable in the lunar gravity. It was, in fact, in our view preferable both to weightlessness and to the Earth's gravity."

Aldrin added,

"One sixth gravity was agreeable, less lonesome than weightlessness, I had a distinct feeling of being somewhere."

Armstrong felt they had landed in a timeless place, with no changes to mark time passing as we know it. Although the astronauts were locked into the time in Texas, at Tranquillity the scene would have been just the same a thousand years ago, and probably will be the same a thousand years in the future. With no atmosphere, they found that everything they could see was starkly clear; features on the horizon were as sharp and clear as the rocks at their feet.

Aldrin looked above the LM. The Earth hung in a black sky; a disk cut in half by the day night terminator. It was mostly blue, with swirling white clouds, and he could make out a brown landmass – North Africa and the Middle East. Glancing down at his boots, he realised that the soil he and Armstrong were stomping through had been there longer than any of those brown continents.

EVA Flight Director Cliff Charlesworth smiles from his console position in the MOCR as the EVA continues.

Screen capture by Colin Mackellar from NASA 16mm footage.

Unveiling the plaque

At 109:52:19 GET (1324:19 AEST) the two astronauts gathered around the Eagle's steps and 'unveiled' a small plaque (by removing its cover) mounted on a strut between the third and fourth rungs of the ladder, to commemorate the historic landing.

Aldrin (centre) and Armstrong unveil the plaque.

Picture through Parkes, from the Apollo 11 TV video restoration.

Armstrong read the inscription aloud,

> "For those who haven't read the plaque, we'll read the plaque that's on the front landing gear of this LM.
>
> First, there's two hemispheres, one showing each of the two hemispheres of the Earth.
>
> Underneath it says 'Here Men from the planet Earth first set foot upon the Moon, July 1969 A.D. We came in peace for all mankind.'
>
> It has the crew members' signatures and the signature of the President of the United States."

Relocation of the TV camera

Armstrong changed the TV camera's wide-angle lens to a normal focal length lens before unveiling the plaque, then with Aldrin helping pull out the cable he set the camera on a stand 18 metres northwest of the LM at 109:55:02 GET (1327:02 AEST).

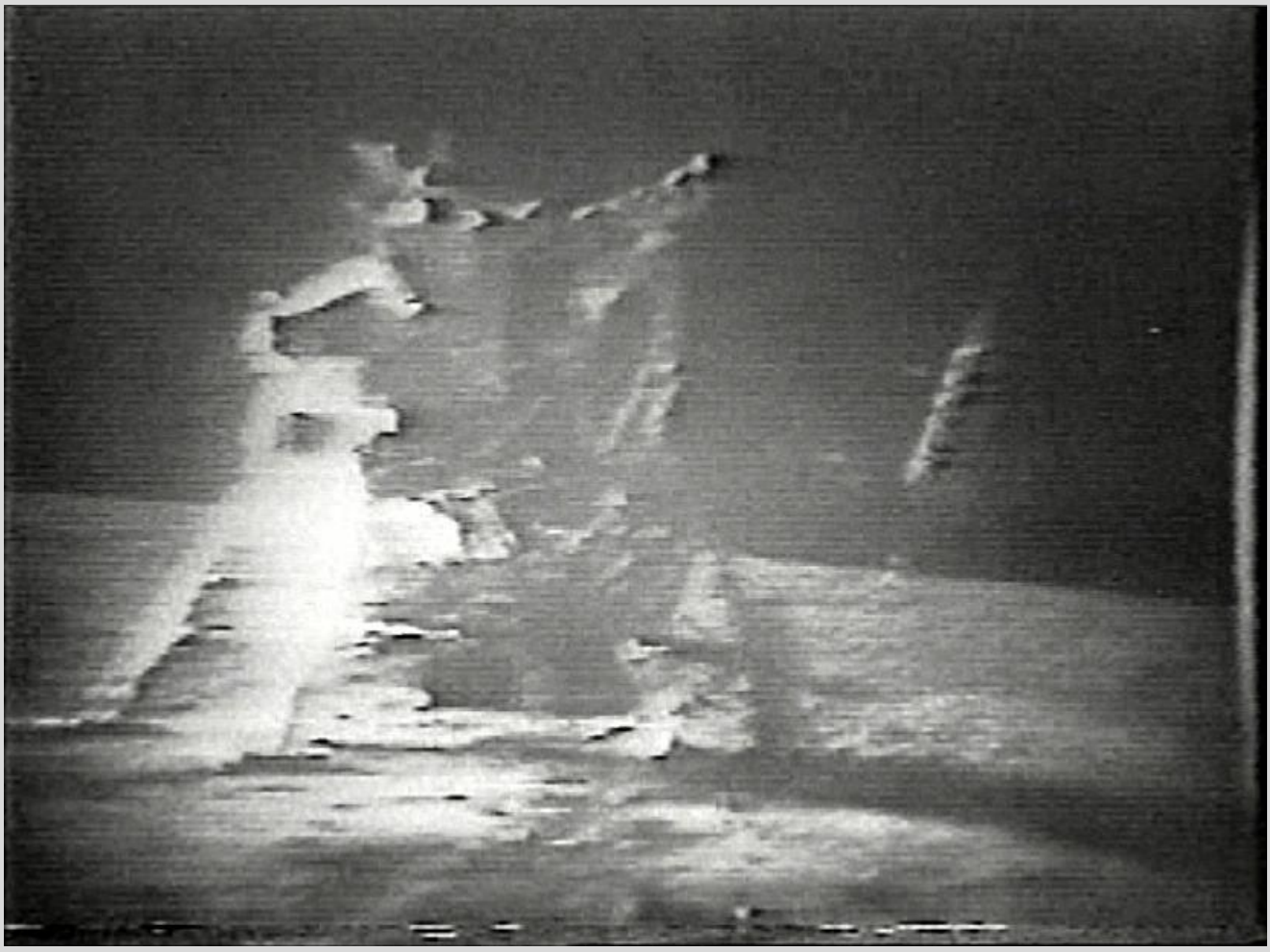
Armstrong, *"Do you think I ought to be further away, or closer?"*

Aldrin, *"Can't get much further away."* The cable length limited the distance.

Armstrong, *"Let's try it like this for a while. I'll get a couple of panoramas with it here."* And he turned the camera around in steps to show the scene around the LM.

Armstrong,

> "The one thing that gave us more trouble than we expected was the TV cable. I kept getting my feet tangled up in it. Fortunately, Buzz was usually able to notice this and kept me untangled. He was able to tell me which way to move my foot to keep out of trouble. Here was good justification for two men helping each other."



Neil has carried the TV camera out to its final position, approximately 18-metres from the LM.

Before he begins to take a series panorama images with it, he captures this, the only TV view of all of Eagle sitting on the lunar surface. Buzz is standing near the ladder. 109:57:45 GET

Screenshot by Colin Mackellar from unrestored Sydney Video tape.

Setting up the flag

Next, not listed on their procedure checklist, at 110:09:43 GET (1341:43 AEST) the astronauts set up the Stars and Stripes flag, finding it difficult to punch the pole into the lunar soil. They found the first 10 centimetres was reasonably easy, but then the regolith hardened, and they only managed to sink it into the soil about 20 centimetres, then leant it so the weight of the flag didn't pull it over.

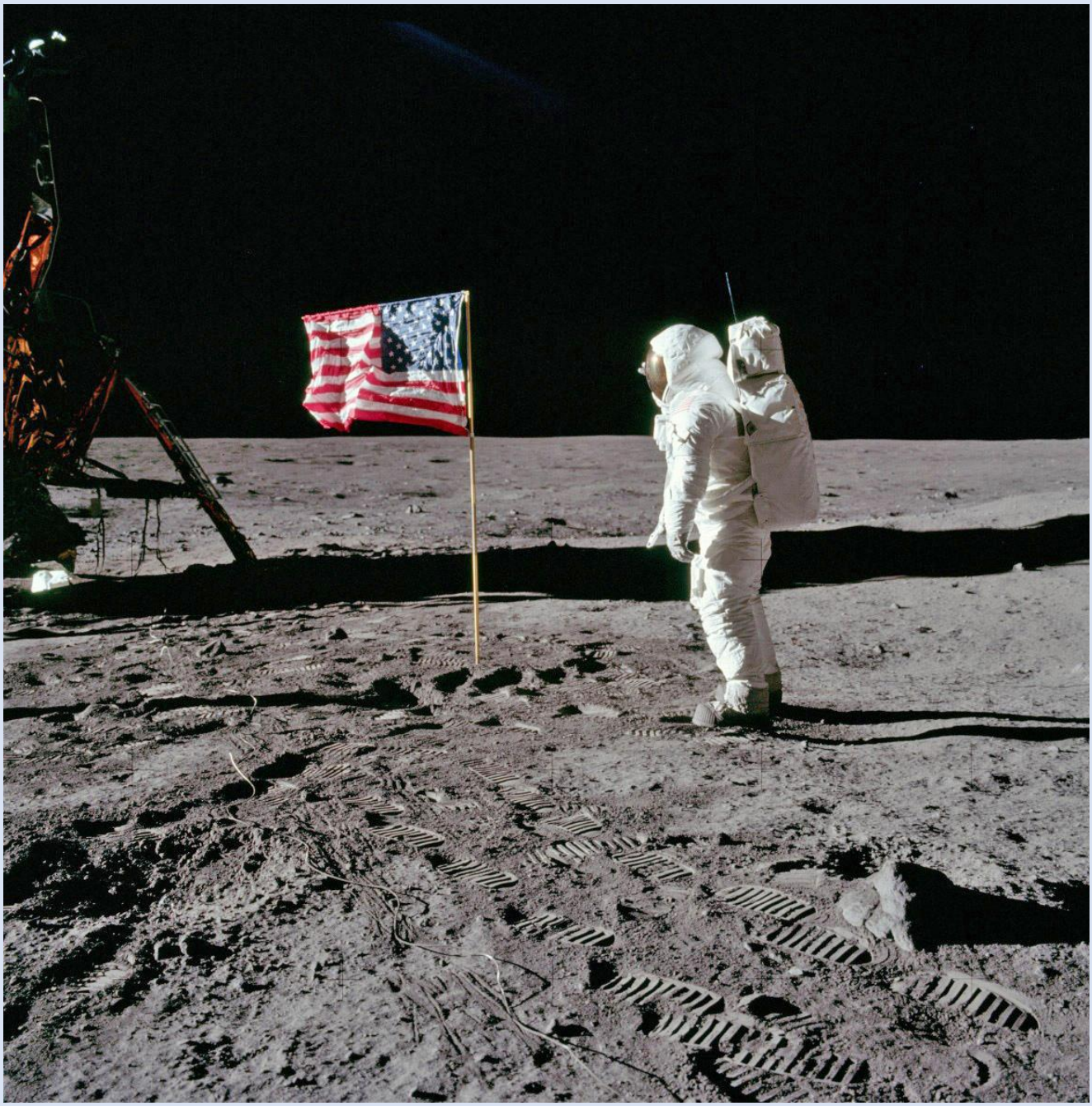
At 110:16:00 GET (1348 AEST) Collins appeared from behind the Moon, tracked by Tidbinbilla. Houston called him,

"Columbia, Columbia, this is Houston. AOS. Over"

Collins: *"Yeah – reading you loud and clear. How's it going?"*

McCandless: "Roger*. The EVA is progressing beautifully. I believe they are setting up the flag now."*

Collins, *"Great!"*



After a debate on which flags to use, it ended up as the Stars and Stripes as the Congress of the USA financed the whole project. It was not a territorial claim but was seen as a symbol of freedom and to identify the nation that achieved the first landing.

Due to temperatures expected to rise to 1,000°C during the lunar landing the flag assembly was stowed in a shroud clamped to side of the ladder on the morning of departure from Earth. Aldrin felt the $US5.50 flag symbolised an “almost mystical unification of all people in the world at that moment,” though he was dreading the possibility of the flag collapsing into the dust in front of the millions of viewers.

As the flag was erected on the lunar surface, an identical flag was raised in the MOCR.
In December 1972, the Apollo 17 mission took this flag to the lunar surface –

Dr Harrison Schmitt, Apollo 17 Lunar Module Pilot

During a video meeting with Australian space trackers on 21 July 2023, Dr. Harrison Schmitt, explained, "That's the backup flag to the one that Neil and Buzz deployed.

Before our mission, I discussed it with Gene Kranz and said, 'Let us take that to the Moon' – and that's what's up there now. 'And we'll bring you one that was taken to the Moon.'

So, the flag in the refurbished MOCR [Mission Operations Control Room] today is one that we brought back from Apollo 17."

At this point Aldrin announced,

> "I'd like to evaluate the various paces that a person can do while travelling on the lunar surface. I believe I'm out of your field of view. Is that right, now, Houston?"
>
> McCandless, "That's affirmative, Buzz."
>
> After a pause, while Buzz ran toward the west and came back toward the LM, "You're in our field of view now."
>
> Aldrin, "Okay. You do have to be rather careful to keep track of where your centre of mass is. Sometimes, it takes about two or three paces to make sure you've got your feet underneath you. About two to three or maybe four easy paces can bring you to a fairly smooth stop."

There was a pause as he turned at the TV camera and then headed toward the LM.

> "To change directions, like a football player, you just have to put a foot out to the side and cut a little bit."

There was another pause as he turned toward the TV camera and started to do a two-footed hop.

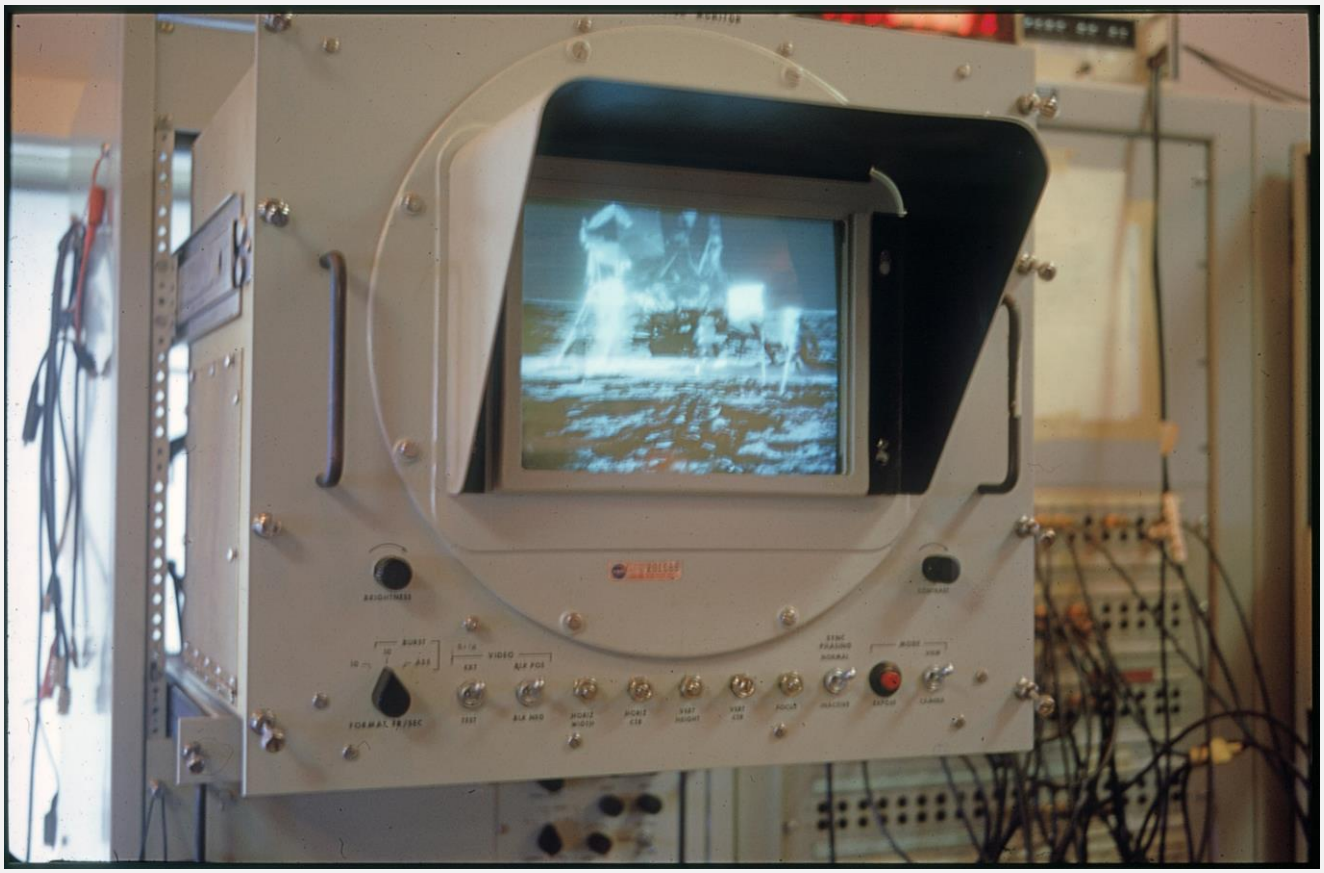
> "The so-called kangaroo hop does work, but it seems as though your forward mobility is not quite as good as it is in the more conventional one foot after another."

Buzz paused, turned at the TV camera, and headed back to the LM.

> "As far as saying what a sustained pace might be, I think that one that I'm using now would get rather tiring after several hundred feet. But this may be a function of this suit, as well as the lack of gravity forces."

President Richard Nixon speaks to the astronauts

In Washington President Richard Nixon was watching the moon walk in the White House with astronaut Frank Borman (Commander of Apollo 8) and Bob Haldeman. It was approaching midnight



David Cooke, Parkes Senior RF Engineer, took this photo of the Parkes Slow Scan monitor, as Buzz Aldrin demonstrates mobility. With thanks to David Cooke. 2018 slide scan by Colin Mackellar.

local time as they were standing around the television set in his private office when they watched Neil Armstrong step onto the moon. They went into the Oval Office next door where the media TV cameras had been set up for his split screen phone call to the moon. Armstrong's voice was coming through loud and clear through Goldstone.

Away up beyond the sky, on the Moon's surface where it was a bright sunlit lunar morning, but 1045 pm Houston time by their watches.

Armstrong and Aldrin were behind the camera when they heard McCandless call them:

> *"Tranquillity Base, this is Houston. Could we get both of you on the camera for a minute, please."*
>
> Aldrin, *"Say again, Houston?"*
>
> Armstrong, *"He wants us [in front of the] camera."*
>
> McCandless, *"We'd like to get both of you in the field of view of the camera for a minute. Neil and Buzz, the President of the United States is in his office now and would like to say a few words to you. Over"*
>
> McCandless, *"All right. Go ahead, Mr President. This is Houston. Out."*

The two lunar walkers moved to the front of the camera and paused to listened to their President. His voice was being transmitted through Goldstone to the lunar surface, and through the Wing at Tidbinbilla to Collins in the CSM. It was 110:16:30 GET, (1348:30 AEST).

Audio

Net 1 audio – 3 min 07 sec / 2.4MB.

Received at Goldstone and recorded at Honeysuckle Creek from Net 1.

Recorded by Bernard Scrivener.

Transferred to digital audio by Mike Dinn.

Edited by Colin Mackellar.

President Nixon:

*"Hello, Neil and Buzz. I'm talking to you by telephone from the Oval Room at the White House, and this certainly has to be the most historic telephone call ever made [from the White House *]. I just can't tell you how proud we all are of what you have done.*

For every American, this has to be the proudest day of our lives. And for people all over the world, I am sure they, too, join with Americans in recognizing what an immense feat this is. Because of what you have done, the heavens have become a part of man's world.

And as you talk to us from the Sea of Tranquillity, it inspires us to redouble our efforts to bring peace and tranquillity to Earth. For one priceless moment in the whole history of man, all the people on this Earth are truly one; one in their pride in what you have done, and one in our prayers that you will return safely to Earth."

* The words "from the White House" were not heard by people listening to the air/ground audio, because they were swamped by the echo of the President's voice coming back from the Moon. The additional words, which reduce the scale of his claim, are clearly heard on recordings made in the Oval Office, and appear on official Presidential transcripts. – C.M.

Armstrong responded with: *"Thank you Mr. President. It's a great honour and privilege for us to be here, representing not only the United States, but men of peace of all nations, and with interest and a curiosity and a vision for the future. It's an honour for us to be able to participate here today."*

President Nixon: *"Thank you very much, and I look forward – all of us look forward to seeing you on the Hornet on Thursday."*

Aldrin: *"I look forward to that very much, sir."*

Aldrin saluted the camera again, followed by Armstrong a moment later. Then, they turned to work, beginning with kicking the dust to see how it behaved, and the task of collecting more samples of moon rocks. Although Armstrong had been warned there might be a special communication during their EVA, and Aldrin was told nothing – neither were prepared for the President's call.

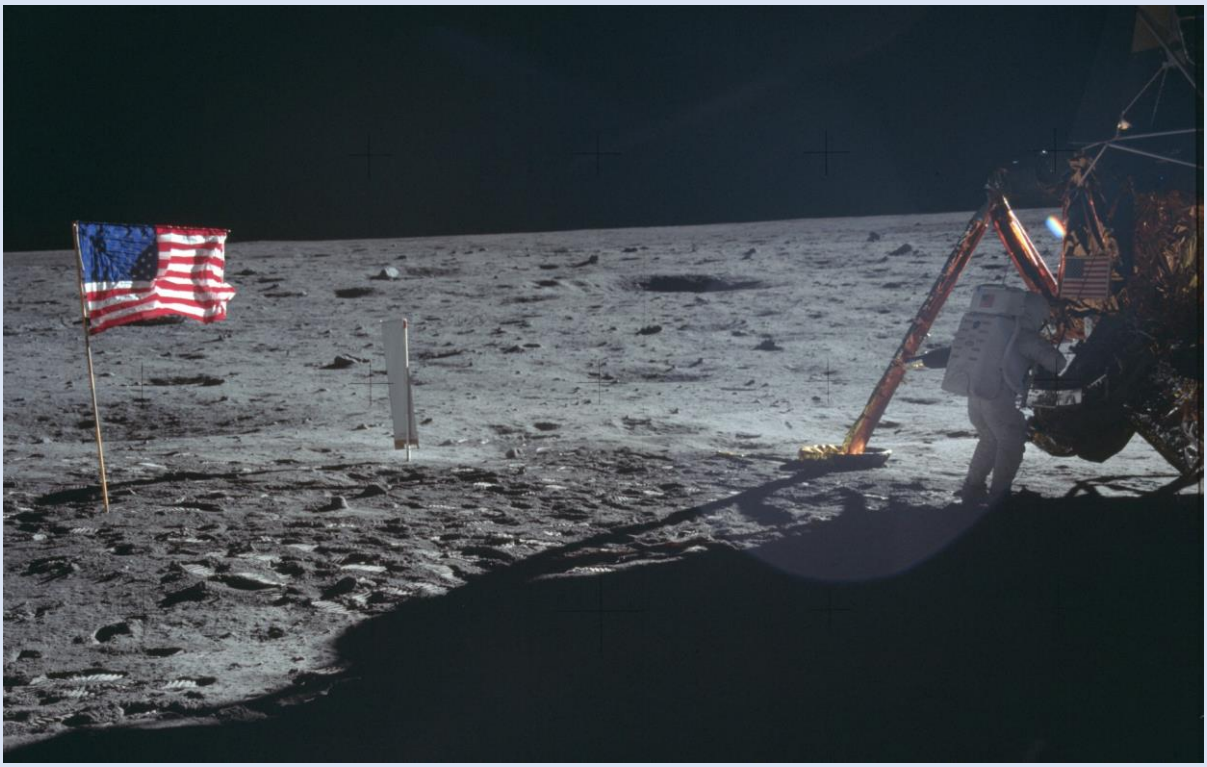
Neil Armstrong (left) and Buzz Aldrin listen to President Richard Nixon in this frame from the restored EVA TV. Picture through Parkes.

Core sample and setting up the EASEP

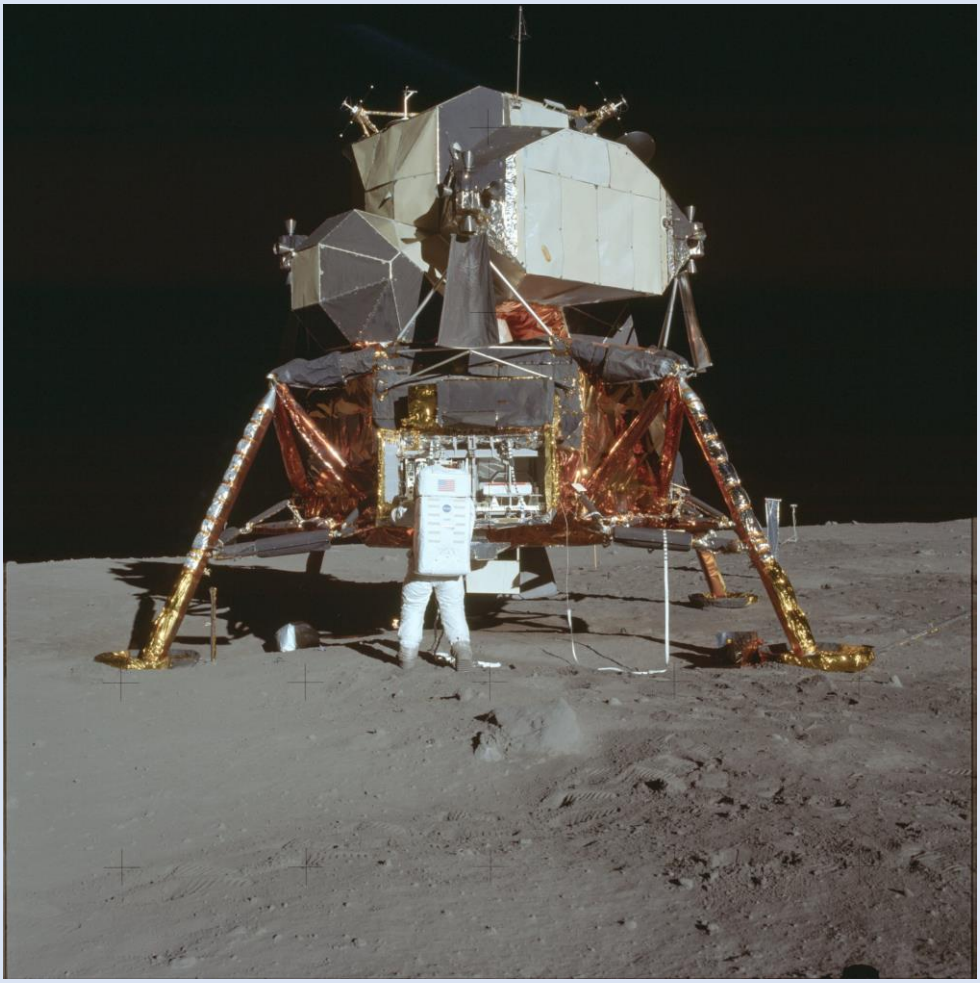
As soon as the President had finished, Armstrong headed for the MESA to begin the geological work, using the next 17 minutes to observe phenomena and collect the bulk samples.

At 110:55:42 GET (1427 AEST) Aldrin began setting out the EASEP (Early Apollo Scientific Experiments Package). It was an important part of the Apollo missions to leave a scientific package on the moon's surface for the tracking stations on Earth to monitor conditions around the landing site after the astronauts left.

Aldrin began with trying to drive a core tube into the regolith, "I picked up the hammer, went out into the vicinity of where the solar wind experiment was, and drove the first core tube into the ground. I pushed it in about 3 or 4 inches (7.6 or 10 centimetres) then started tapping it with the hammer." From that moment he found he could make little progress, no matter how hard he tried to belt it in with the hammer. He managed another 5 centimetres, but it tended to want to fall over. He had no difficulty pulling it out and found the core sample had no inclination to fall out of the tube. It seemed to have the cohesiveness of wet sand.



One of the few photos of Armstrong on the surface, here working at the MESA.
NASA image AS11-40-5886. Johnson Space Center.



Buzz Aldrin working at the LM.
NASA image: AS11-40-5927. Johnson Space Center.

Aldrin tried another location with the same results before changing over to setting out the EASEP. He began with the seismometer [see separate EASEP/ALSEP essay for details of EASP]. The EASEP instruments measured particles from the sun, the moon's seismic activity, and a laser beam reflector for accurately measuring the distance between the Earth and moon. Carnarvon's 9-metre dish was scheduled to track EASEP, at times it was the prime support.

At 111:20:00 GET (1452:00 AEST) Armstrong spotted a sizeable crater about 20 metres to the east of the LM and veered over to inspect it and take some pictures, "I had some personal reservations in taking the time to go over and snap a picture of the crater, but I thought it was of sufficient interest that it was worth getting." He estimated it was almost 24 metres in diameter and up to 6 metres deep and found the sides of the crater showed signs of layering that he thought the geologists would be interested in. For a moment he thought of it as a baby crater which made him think of his little daughter who had died of a brain tumour, and called it Muffie's Crater, with an image of her sliding down the sides to the bottom.

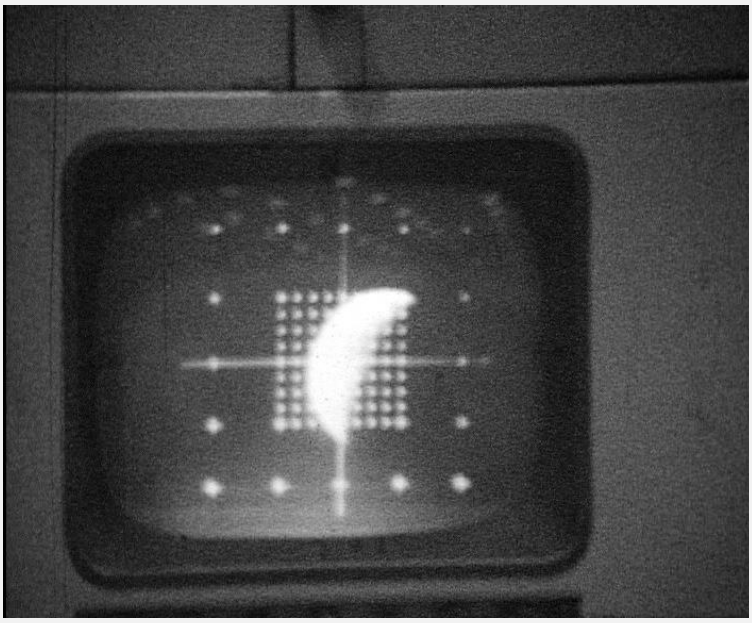
Back to the Lunar Module

At 111:20:00 GET (1452 AEST) Aldrin collected the Solar Wind Experiment panel and climbed back into the LM.

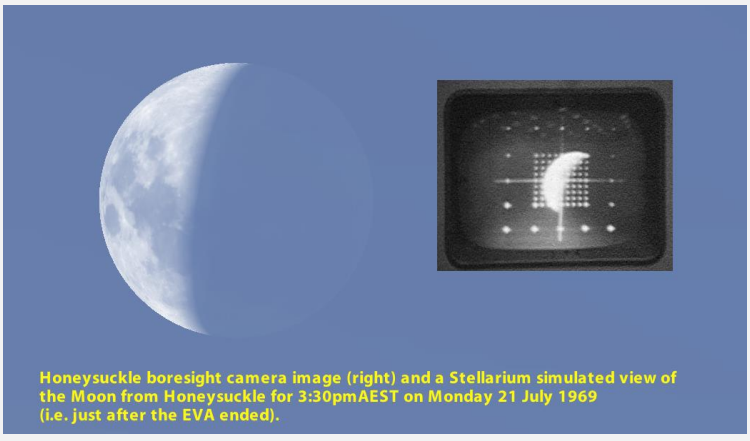
Armstrong threw a rock with the comment, *"You can really throw things a long way out here."* As he darted about collecting the rock samples, his pulse rate went up from 90 to 140, peaking at 160, as he hauled the samples up into the LM with a special tackle called the LEC (Lunar Equipment Conveyor) he nick-named the 'Brooklyn clothesline.'

Aldrin found the first step of the ladder was a good height, but Armstrong could leap the 1.8 metres directly to the third step, "I did a deep knee bend with both legs and got my torso down absolutely as close to the footpad as I could. I then sprang vertically up and guided myself with my hands by use of the handrails."

At 111:39:13 GET, (0011:13 spacecraft time, USCDT) (1511:13 AEST) the hatch was closed to complete a 2 hour 31 minute 40 second, 1 kilometre moonwalk. The extent of Armstrong and Aldrin's excursions around the LM could be contained within a football pitch.



The boresight television camera shows Honeysuckle Creek's 85-foot antenna is pointed straight at Tranquility Base. From the Super 8 movie by Ed von Renouard, at around 3:30pm Monday 21 July 1969.



Here's a simulated view for comparison. (The boresight TV picture is rotated as the antenna turns on its axes to follow the Moon, which is why the orientation doesn't match the simulated view.)

Image: Boresight camera (right) and a simulated view of the Moon from HSK for 3:30pm AEST, 21 July 1969.

As the two astronauts struggled with the rocks and suits in the cramped LM cabin there was a 10-minute break in voice communications with the ground as they had to fold their backpack antennas to avoid damage to the LM's interior.

Their first chore was to pressurise the LM's cabin and to begin stowing the rock boxes, film magazines, and anything else they wouldn't need until they were docked again with Columbia.

They removed their boots and the EMU's, opened the hatch and threw them onto the lunar surface with any other gear not required on the journey back home. They had to clear enough space so the two could find room to sleep.

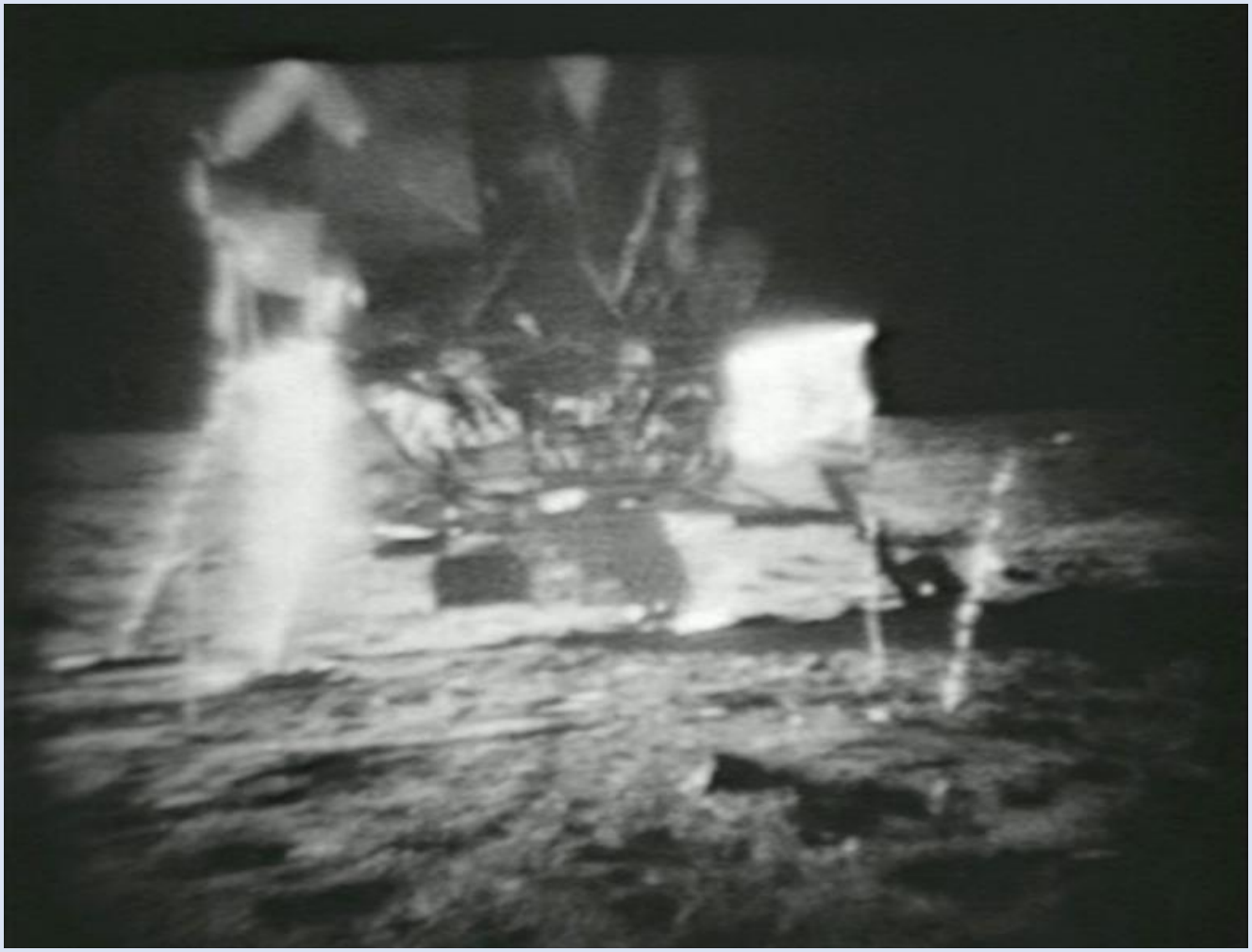
PLSS dumped

Houston did not miss anything…

> "Roger, Tranquillity. We observed your equipment jettison on the TV and the passive seismic experiment recorded shocks when each PLSS hit the surface – over."
>
> "You can't get away with anything anymore, can you?" Armstrong registered a jocular complaint.

They expected the lunar dust particles to float around inside the LM, but were surprised to find that they never did, generally staying where they lodged, probably due to the fact they were so dry they were attracted to anything with static electricity. This meant they were able to remove their helmets without the worry of the dust getting in their eyes and noses.

When asked if there were any surprises on the Moon Armstrong responded with:



Honeysuckle Creek's Ed von Renouard captured the PLSSs being dumped on his Super 8 movie camera.

In this frame, the second backpack is dumped down the ladder.

It has just been pushed out of the door and is on the porch, about to tumble end over end down the ladder. The first PLSS rests at the bottom of the leg.

Taken from Ed von Renouard's Super 8 movie of the scan converted monitor at HSK. Screenshot: Colin Mackellar.

"I was surprised by a number of things – I can't recall them all now, but I was surprised at the apparent closeness of the horizon. I was surprised at the trajectory of dust you kicked up with your boot. You never had a cloud of dust there. That's a product of not having an atmosphere.

I was absolutely dumbfounded when I shut the rocket engine off and the particles that were going out radially from the bottom of the engine fell all the way out over the horizon, and when I shut the engine off, they raced out over the horizon and instantly disappeared. I'd never seen anything like that."

Back inside Eagle, Neil and Buzz take each other's photograph after their successful

At 114:33:30 GET (1805:30 AEST) the Green Team at Mission Control changed shift over to the Maroon Team and the new Capcom Owen Garriott conducted a debriefing with Eagle's crew.

Time to rest and get some sleep

At 114:52:00 GET (1824:00 AEST) the tired astronauts finally put blinds over the windows and curled up to rest. They both decided to sleep with their helmets and gloves on, hoping there would be less noise, they would be warmer, there was less chance of breathing lunar dust, and they would not have to find somewhere to stow them.

The later missions supplied hammocks for sleeping, but not for Apollo 11, so Aldrin lay on the floor with his feet up against the side, or bent his knees, as the cabin wasn't wide enough to stretch out. Armstrong sat on the cover of the ascent engine, leaned against the rear of the cabin, and suspended his legs through a loop of waist tether he had rigged up from a handhold. After he settled down Armstrong found there was an annoying pump gurgling somewhere near his head, and he could not avoid seeing the Earth glaring at him like a big blue and white eyeball through the Alignment Optical Telescope, so he had to get up and block the Earth light off. The window blinds did not block light out enough either, in fact they could see the horizon through them. It was a never-ending battle to get a minimum level of sleeping conditions, "… and we never did. Even if we had, I'm not sure I would have gone to sleep," admitted Armstrong.

After a rest period of 12½ hours, both astronauts agreed they did not sleep very well. Apart from the emotional high from excitement of the day they became progressively colder, though they tried turning the suit water temperature up to maximum, then disconnecting the water flowing through their suits. Aldrin finally adjusted the temperature of the airflow through the suit, and they felt better. Although it was over 93°C outside, the cabin temperature was steady at 16°C. Dr. Kenneth Biers at Houston said the data he received from Armstrong (they were not monitoring Aldrin) indicated that he may have slept fitfully and dozed but stirred around quite a bit. Armstrong admitted he found it hard to unwind after the excitement of the day. He wasn't concerned that lack of sleep would affect his concentration flying the LM the next day.

Buzz Aldrin took this portrait of an elated but tired Neil Armstrong inside the Lunar Module after the EVA. Image AS11-40-5874. This and the two above, courtesy of the Apollo Image Gallery.

Bryan Sullivan in computers remembers driving home at the end of his shift,

> "For once our long car trip home that day was very quiet as we all contemplated the events of this extraordinary event.
>
> I was still hyped on coffee and adrenalin as I arrived home. My wife's first words to me were: 'I was worried! What made Armstrong spring back up onto the ladder as soon as he'd put his foot on the surface? Had he seen something horrible? Did he get a fright?' I explained that it was a safety procedure to make sure he could actually get up the ladder again in the bulky spacesuit."

HSK MISSION DAY 6

Tuesday 22 July 1969

Heading Home

LM Liftoff: 124:22:01 GET 0354 AEST
only Madrid tracking.

Docking: 128:03:00 GET 0735 AEST
Goldstone and Madrid tracking.

LM Jettison: 130:09:31 GET 0941 AEST
only Goldstone tracking.

Lunar stay period:
21 hours 36 minutes 21 seconds.

LM/CSM separation period:
27 hours 51 minutes.

TEI burn: 135:23:42 GET 1455:42 AEST

FINAL LUNAR ORBITS

HSK Prime LM

Orbit		Track Duration
29 AOS: 1142:00 AEST	LOS : 1231:56	0h 49m 56s
30 AOS: 1317:45 Two-way		
Final CSM orbit around the Moon		
LOS : 1429:48		1h 12m 03s

HSK Wing CSM

Orbit		Track Duration
29 AOS: 1157 AEST	LOS: 1231:43	0h 55m 56s
30 AOS : 1317:45 AEST	LOS : 1429:48	1h 12m 03s

At 121:40:36 GET (1012:36 spacecraft time USCDT) on July 21 (0112:36 AEST 22 July) the LM astronauts were woken up by Ron Evans, the Houston Capcom with,

> *"How is the resting – standing up there? Did you get a chance to curl up on the engine can?"*
>
> Aldrin: *"Roger, Neil has rigged himself a really good hammock with a waist tether, and he's been lying on the ascent engine cover, and I curled up on the floor."*

After more than 21½ hours on the lunar surface, the two lunar explorers prepared their ship for lift off. Ron Evans in Houston passed a message up:

> *"Our guidance recommendation is PNGCS, and you're cleared for take-off."*
>
> Aldrin: *"Roger, understand, we're No 1 on the runway."*

LUNAR LAUNCH

Just one minute behind the Flight Plan scheduled time at 124:22:01 GET (1254 spacecraft time July 21) (0354 AEST 22 July), the rocket engine that had to fire, fired.

Aldrin:

> "Okay, master arm on 9... 8... 7... 6... 5... abort stage, engine arm ascent, proceed. That was beautiful."
>
> "26, 36 feet per second up. Be advised of the pitch over. Very smooth... very quiet ride...."

Pushed by the 1,587-kilogram thrust of the LM ascent engine for seven minutes 14.9 seconds, the tiny spacecraft shot up into the black lunar sky, picking up speed from 48 kilometres per hour after 10 seconds to 2,890 kilometres per hour. The astronauts heard no sounds but only felt the acceleration and a high frequency vibration through their feet. As the rocket's exhaust gases shredded the gold foil insulation and sprayed the pieces around the landing place, Aldrin looked out of the window long enough to see their flag topple over in the blast from the rocket motor.

Only Madrid was tracking the LM as it soared up into the black lunar sky.

Audio

Hear the onboard audio and Flight Director's loop of the ascent.

Link takes you to a page on the HSK website with multiple recordings from various flight loops, and with additional information.

Seconds after liftoff, the LM pitched forward about 45 degrees, and though the astronauts had anticipated it would be an abrupt manoeuvre, the harnesses securing them cushioned the tilt enough to make it barely noticeable. Both astronauts were busy with their respective tasks, Aldrin working on the computer, and Armstrong keeping track of the flight and navigation. Armstrong commented, "I observed one sizeable piece of the spacecraft flying along below us for a long period of time after lift-off. I saw it hit the ground below us somewhere between one and two minutes into the trajectory."

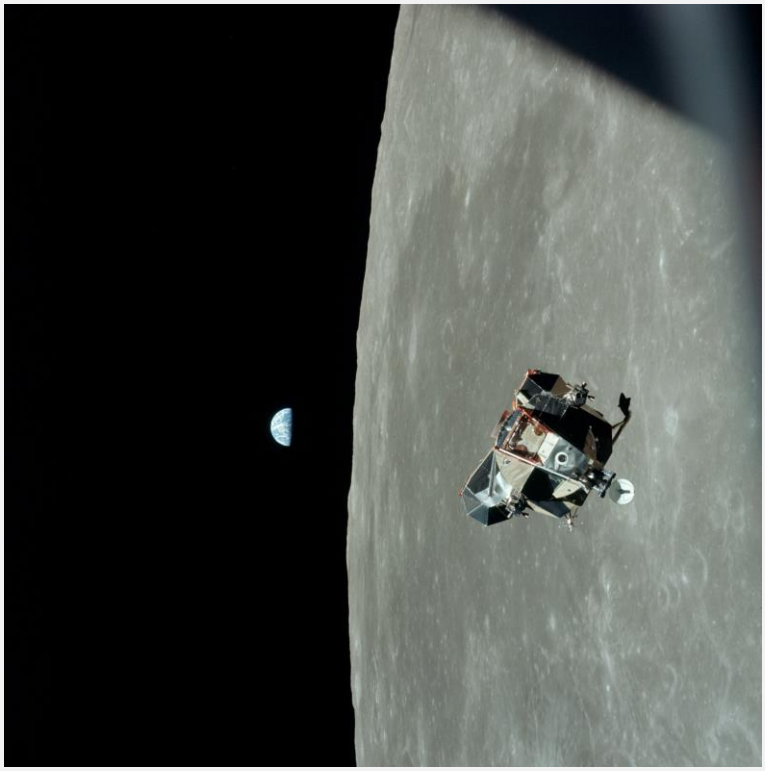
Evans: *"Eagle, Houston. You're go at three minutes, everything's looking good."*

Armstrong: *"Roger."*

Armstrong: *"We're going right down US one."*

Spearing upwards the astronauts had a very different ride from the descent. Now they were facing down and could see the lunar surface scrolling past, while experiencing a rocking-chair movement as the thrusters fired intermittently.

With the ascent stage of the LM on its way home the two astronauts now began to feel confident that Apollo 11 was really going to make it. There had been no real surprises on the moon's surface after all.



"I got the Earth coming up... it's fantastic," shouted Collins as he grabbed his camera to get the Moon, Earth, and returning Ascent Stage of the LM approaching him, all in one picture.
Photo courtesy of the Project Apollo Archive.

Eagle returns to Columbia

Up in the Command Module Collins was preparing to meet his companions with a book of 18 different procedures to rendezvous slung around his neck.

While Columbia kept a steady course 97 kilometres above the lunar surface, Eagle climbed into a 75.6 kilometres orbit and soon Collins had a radar lock on it, showing it to be 400 kilometres behind. As the Earth waited for the two spacecraft to emerge from behind the moon, it wasn't long before Collins could see a tiny blinking light in the darkness, then as they passed over the landing site, Eagle was only 24 kilometres below, and 80 kilometres behind.

As they entered into sunlight on the back side, Collins saw the blinking light slowly resolve into the LM skimming over the crater scarred surface below but looking quite different now without the descent stage and its dangling legs. Armstrong took up a position 15 metres from Columbia and kept station. The rendezvous was over and for the first time the astronauts began to feel they were going to bring this amazing stunt off.

At Honeysuckle we were beginning our SRT for the day's track.

Back together again. Eagle successfully docks with Columbia

As they came around the rim of the Moon Houston was agog to know how things were going, but not wanting to interfere with the docking process: "Eagle and Columbia, Houston standing by."

"Roger, we're station keeping," Armstrong's pithy response told Houston everything. All three astronauts steeled themselves for this critical moment docking the two spacecraft together again. The success of the mission; their return home; their lives, relied on switches, relays, mechanical latches, and valves all working faultlessly, complementing their own skills. At 128:03:00 GET (0735 AEST) the LM's docking probe gently entered the cone, and with a satisfyingly loud thud the twelve latches slammed home to lock Eagle and Columbia together again.

Then, just as they began to feel they were safely together again, the spacecraft suddenly began jerking around, both spacecraft thrusters firing in anger. The astronauts all jumped, thinking they might be in trouble, but it was the LM and CSM automatic attitude systems competing with each other until the LM's automatic pilot was turned off and the spacecraft quietened down to wait for the astronauts' next instructions.

Armstrong: *"Okay, we're all yours, Columbia."*

Collins: *"Okay.... I'm pumping up cabin pressures.... that was a funny one. You know, I didn't feel it strike and then I thought things were pretty steady. I went to retract there, and that's when all hell broke loose. For you guys, did it appear to you to be that you were jerking around quite a bit during the retract cycle?"*

Armstrong: *"Yeah. It seemed to happen at the time I put the plus thrust to it, and apparently it wasn't centred because somehow or other I got off in attitude and then the attitude HOLD system started firing."*

Collins: *"Yeah, I was sure busy for a couple of seconds."*

They were back together again just a mere three minutes behind the time specified by the original Flight Plan published many months earlier, an amazing achievement considering what they had been through.

Aldrin was first through the hatch, with a triumphant grin on his face. Collins gleefully shook his hand, then turned to the tunnel to welcome Armstrong, and an excited reunion took place, before they dragged the lunar rock bags into the Command Module. It took 2 hours to configure the systems and prepare to ditch the LM.

The LM is jettisoned

Going behind the moon for the 29th time, Collins threw the right switches, and at 130:09:31 GET (0941:31 AEST) at an altitude of 114 kilometres, with a slight bang, the LM backed off, watched sadly by Armstrong and Aldrin. Collins, though, was very pleased to see it steadily disappearing into the distance, taking all its complications with it. Armstrong commented, "Jettison went as planned. The separation was slow and majestic; we were able to follow it visually for a long time." The Eagle would continue to circle the moon until it finally joined the other spacecraft corpses on the lunar surface.

TEC–Day 1

COMING HOME

HSK Prime

Track Duration

CSM
AOS: 1506:15 Two-way LOS: 1930:00 4h 23m 45s

Handover uplink Prime to Wing:
1743:41
2-way duration: 2h 37m 26s

EASEP
AOS: 1946:28 AEST LOS: 2145:00 1h 58m 32s

CSM
AOS: 2152 LOS: 2342:00 1h 50m

HSKX Wing

LM Rev 32 **Track Duration**
AOS: 1714:37 Two-way LOS: 1731:25 0h 16m 48s

At 1741 AEST a twx message advised no further LM support was required.

HSKX Wing reconfigured for CSM support.

AOS CSM: 1737:38 LOS: 2342:00 6h 04m 22s

Handover uplink Prime to HSKX Wing:
1743:41

Handover uplink HSKX Wing to MAD:
2304:08 2-way duration: 5h 20m 27s

Trans Earth Injection (TEI) Heading for home

An orbit later, behind the Moon, at an altitude of 97 kilometres, they carefully lined up the horizon and checked they were in the right attitude before firing the SPS motor for 2 minutes 31.41 seconds on time at 135:23:42 GET (1455:42 AEST) to set them on a safe course for home at an initial speed of 9,424.5 kilometres per hour. The CSM had completed 30 orbits of the Moon in 59 hours 30 minutes 26 seconds.

"Just about midnight in Houston town," mused Armstrong nostalgically.

Honeysuckle Creek's antenna was pointing at the edge of the moon, waiting for the first signs of a signal. In the spacecraft the astronauts saw the Earth rise above the moon's horizon for the last time and the voice of Charlie Duke in Houston filled their earphones:

The Moon quickly recedes.

NASA photo AS11-44-6661 courtesy of the Apollo Image Gallery.

Duke: *"Hello, Apollo 11, Houston. How did it go? Over."*

Collins: *"Tell them to open up the LRL (Lunar Receiving Laboratory) doors, Charlie."*

Duke: *"Roger. We got you coming home. It's well stocked."*

Audio

Hear AOS as Apollo 11 rounds the Moon following the TEI burn – as recorded at Honeysuckle from Net 1.

1.1MB mp3 file runs for 3:04.

Recorded by Bernard Scrivener at Honeysuckle. Tape transferred by Mike Dinn, edited and digitised by Colin Mackellar.

As they left the Moon, the three astronauts looked back at the huge grey and tan orb suspended in front of them it was an awesome moment to realise where they were and what they had just done.

They tried to use the remaining film to take as many pictures as possible of the moment. Collins, however, felt that he never wanted to return. 8,000 kilometres from the moon, the three weary space travellers were able to catch up on their sleep, turning in at about 0530 spacecraft time.

They set up the Passive Thermal Control (PTC) rolling at 0.3°/second but this time they had a pitch angle of 270° instead of the 90° on the way out. A rest period began at 137:22:00 GET (1654:00 AEST) with the following final exchange of the historical day:

Capcom Garriot, *"How do you read me through Honeysuckle now? Over."*

Collins, *"You're loud and clear, Owen."*

Garriott, *"Okay, thank you."*

Collins, *"I'll tell you. Purple people keep funny hours"*, referring to Garriott as Capcom of the Maroon Team.

HSK MISSION DAY 7

TEC–Day 2

Wednesday 23 July 1969

HSK Prime

CSM **Track Duration**

AOS: 1322 AEST LOS : 0001 (Thur) 10h 39m

Handover uplink GDS to HSK:
1532

Handover uplink HSK to MAD:
2347:01

2-way duration : 8h 15m 01s

HSKX Wing

CSM **Track Duration**

AOS: 1145 AEST LOS: 0001 (Thur) 12h 16m 00s

After about ten hours rest, the astronauts were left to wake up on their own at 147:37:00 GET (0309:00 AEST).

They passed through the gravity hump between the moon and Earth at 148:7:22 GET (0339:22 AEST) eating their breakfast, 322,021 kilometres from Earth, and 62,553 kilometres from the moon. Columbia now began picking up speed as the Earth's gravity strengthened.

There had been a major effort to try and locate exactly where Apollo 11 had landed in the Sea of Tranquillity, and they were still trying to pinpoint the position when Armstrong dropped a casual remark during a debriefing as they were returning to Earth,

> "I took a stroll back to a crater behind us that was maybe seventy or eighty feet in diameter and fifteen or twenty feet deep. And took some pictures of it. It had rocks in the bottom...."

That description was all the geologists needed they immediately knew the landing spot from their maps, confirmed by pictures from the 16mm sequence camera of the landing: 0° 41'15" North latitude, 23° 25'45" East longitude. If only Armstrong had mentioned that crater before!

At 155:36:00 GET (1108:00 AEST) there was an 18-minute television show, starting with pictures of the Moon and Earth. Capcom Charlie Duke in Houston mistook the Moon on his large monitor for the Earth, and was ragged by the astronauts:

> Aldrin, *"You haven't got the right planet."*
>
> Duke, *"I'll never live that one down."*
>
> Collins, *"We're making it get smaller and smaller to make sure that it really is the one we are leaving."*
>
> Duke, *"Aw, that's enough you guys."*

Armstrong showed the boxes of lunar samples to the camera for the scientists,

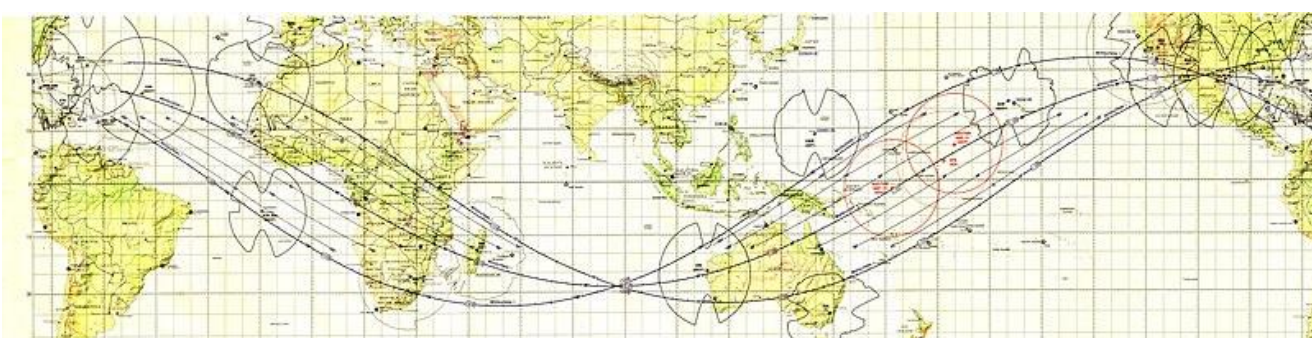
> *"These two boxes are the sample return containers. They are vacuum packed containers that were closed in a vacuum on the lunar surface, sealed, and then brought inside the LM and put inside these fibreglass bags, zippered and re-sealed around the outside and placed in these receptacles in the side of the Command Module."*

Collins tried to show sipping water from a teaspoon for the kids that may be watching, then showed how they actually drank water using a water gun,

> *"We really have a water gun which I'll show you. This cylindrical thing on the end of it is a filter with several membranes. One allows water to pass, but not any gas. The other allows gas to pass, but not any water, so we're enabled to drink purified water without the gas in it."*
>
> Duke*, "Thank you from all us kids in the world, here in the MOCR, who can't tell the Earth from the Moon!"*

At 159:53:43 GET (1525:43 AEST) the crew celebrated the half-way point by distance – 269,620 kilometres to go. Another sleep/rest period began at 160:42:00 GET (1614:00 AEST).

As Columbia returned to Earth a crescent Earth filled their windows ahead.



HSK MISSION DAY 8

TEC–Day 3

Thursday 24 July 1969

HSK Prime

CSM **Track Duration**

AOS: 1152:50 AEST LOS: 1632:00 4h 39m 10s

Handover uplink GDS to HSK:
1217:00

Handover uplink HSK to Guam:
1356:00 2-way Duration : 1h 39m

EASEP

AOS : 1728:00 LOS : 0017:45 (Fri) 6h 49m 45s

CSM

AOS: 0047:00 LOS : 0231:09 (Fri) 1h 44m 9s

HSKX Wing

CSM **Track Duration**

AOS: 1159 AEST LOS : 0231:16 (Fri) 14h 32m 16s

The crew slept soundly for 7 to 8 hours until Capcom Owen Garriott called them at 170:59:56 GET (0231:59 AEST).

Meanwhile at the Guam tracking station a ten-year-old boy saved the day. A bearing had seized from lack of grease, immobilising the antenna, and no adult could reach it through a narrow hole for a quick fix. So, Charles Force, the Station Director, called on Greg, his son, to reach in and apply the grease. Neil Armstrong later thanked the lad personally.

During the last evening in Houston at 177:32:00 GET (0904:00 AEST), 169,219 kilometres from Earth, they sent their final television session, rather a philosophical one.

Collins pointed out the number of components involved in the whole spaceship and said,

> "We have always had confidence that all this equipment will work, and work properly, and we continue to have confidence that it will do so for the remainder of the flight.
>
> This operation is somewhat like the periscope of a submarine. All you see is the three of us, but beneath the surface are thousands and thousands of others, and to all those, I would like to say thank you very much."

Part of Aldrin's talk said:

> "We have come to the conclusion that this has been far more than three men on a voyage to the moon. More still than the efforts of one nation. We feel that this stands as a symbol of the insatiable curiosity of all mankind to explore the unknown."

Armstrong wound the session up with:

> "The responsibility for this flight lies first with history and with the giants of science who have preceded this effort. Next with the American people, who have through their will, indicated their desire. Next to four administrations and their Congresses for implementing that will. And then to the agency and industry teams that built our spacecraft the Saturn, the Columbia, the Eagle and the little EMU, the spacesuit and backpack that was our small spacecraft out on the lunar surface. We would like to give a special thanks to all those Americans who built those spacecraft, who did the construction, design, the tests and put their hearts and all their abilities into those craft.
>
> To those people tonight, we give a special thank you, and to all those people that are listening and watching tonight, God bless you. Good night from Apollo 11."

At 1217 AEST Goldstone handed over two-way tracking to Honeysuckle Creek on the spacecraft omni antennas, then we handed over to Guam at 1356.

At 1632:00 AEST Honeysuckle Creek Prime broke track from Apollo 11, leaving the Wing looking after the CSM while we crossed over to lock on to EASEP and we had a quiet period tracking a blind and dumb box before returning to the excitement of re-entry.

Return to Earth

At 189:28:35 GET (2100:35 AEST) the astronauts woke up for their last day in space and prepared for splashdown. They had to separate from the Service Module before they came scorching into the 64 kilometres wide corridor at nearly 40,000

kilometres per hour. The entry corridor into the Earth's atmosphere is extremely critical, too steep an entry would burn them up, and too shallow an entry would make them skip out into solar orbit, to be lost forever.

HSK MISSION DAY 9

TEC Day 4

Friday 25 July 1969

Arriving back home on Earth

HSK Prime

CSM	**Track Duration**
AOS: 0047 AEST Final LOS: 0231:44	1h 44m 44s

HSKX Wing

CSM	**Track Duration**
AOS: 0047 AEST Final LOS: 0231:31	1h 44m 31s

Jettison the Service Module

During the final moments of our track, at 194:49:12 GET (0221:12 AEST), they jettisoned the Service Module and prepared for re-entry. The 4.9 tonne Apollo 11 Command Module was all that remained of the original vehicle of 3,198.4 tonnes that left the Earth over eight days before.

Re-entry

Moments after Honeysuckle Creek lost Apollo 11's signal for the last time, while the Houston controllers were working around their lunch breaks, Columbia dived into the Earth's atmosphere 122 kilometres above the Earth at 39,715.4 kilometres per hour at 195:03:05 GET (0235:05 AEST). Strapped to their couches the now thoughtful, subdued astronauts looked out of the spacecraft windows to see the black of space gradually turn to a shimmering orange yellow tongue of flame with blue-green edges. It grew in intensity with the denser air, until it became an eyeball searing white, covering the entire window.

The crew said it was quiet, Collins commenting, "There wasn't any sizzling, popping or any noises that you commonly associate with entry heating. I thought it was smooth." The temperature of their heat shield, only inches away behind their backs, was reaching a blistering 2,800°C as the ablative material roasted and streamed off into the superheated wake.

The three astronauts also began to feel the effects of gravity, gradually pressing them harder and harder until they were under six and a half times the pressure of normal gravity, which after their weightless days, seemed enormous, dragging their arms down, but luckily it didn't last long.

Drogue and Main chutes deployed

Right on time at 195:12:06 GET (0244:06 AEST) the small drogue parachutes whipped out and flogged around in the slipstream, before hauling the three main orange-and-white striped parachutes out, and the spacecraft began floating down through some stratocumulus clouds. To the astronauts, trying to adjust to the now heavy weight of their arms and legs, it was a pleasant welcome back to Earth to see familiar clouds and soft atmospheric haze again in contrast to the stark, contrasty light of space and the lunar surface.

At Honeysuckle Creek we listened to the last moments of the mission on our headsets as we shut down our equipment and prepared to drive home. For us, a very successful mission was over. It was now time to party.

The Apollo 11 re-entry, photographed from a USAF KC-135 at 43,000 feet. Here, the Service Module disintegrates. See the footage here.

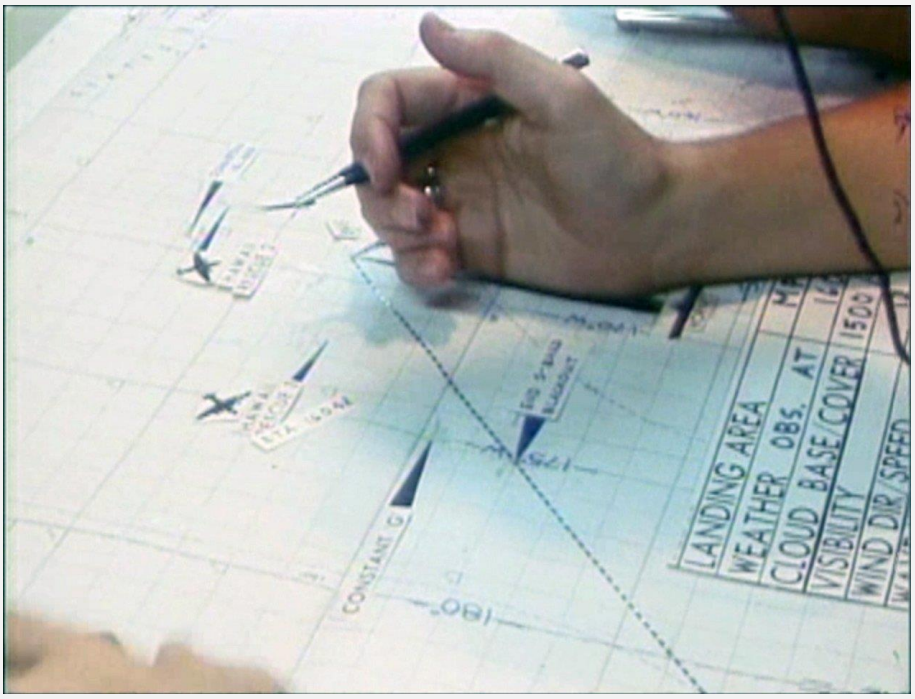
SPLASHDOWN!

Ground Elapsed Time (GET):

195h 18m 35s 0250:35 AEST Friday 25 July 1969

The final moments of the mission were threatened by a deadly thunderstorm, with tops rising to 50,000 feet, brewing over the planned landing area. Rear Admiral Don Davis, commander of Task Force 30, aboard the prime recovery ship USS Hornet, ordered the recovery forces to move 398 kilometres down range. This proved a wise move as the new area had good conditions with 1-metre-high waves and a 16-knot breeze. Columbia changed its inbound trajectory using a modified skip manoeuvre to redirect its course to the new target.

Recovery Room



Columbia's splashdown position is plotted in the Recovery Room, adjacent to the MOCR in Building 30 for display on the large projection screen. Screenshot from NASA 16mm footage.

Dawn was just breaking when Columbia was spotted entering some clouds from the USS Hornet nine minutes before splashdown, coming into view again, swinging gently under its three parachutes. The Apollo 11 mission ended at 195 hours, 18 minutes 35 seconds GET, 1150:35 spacecraft time (0750:35 local Hawaii time) on Thursday 24 July. It was 0250:35 the next morning for us at Honeysuckle Creek, when the Command Module splashed down into the Pacific Ocean, just 1,530 kilometres southwest of Honolulu. This was just 24 seconds ahead of the time specified in the original Flight Plan, published on 1 July 1969, an amazing achievement!! The return voyage from the Moon had taken 59 hours 36 minutes 52 seconds.

The spacecraft landed upside down (Stable 2 position) with the astronauts hanging head down by their straps, staring at the sloshing seawater through the windows. It took the floatation bags almost 8 minutes to flip it over to an apex up mode (Stable 1 position), allowing access to the astronauts. Armstrong commented, "The wave height was between three and four feet, but it looked more like thirteen or fourteen. And it felt like it too."

Armstrong called Air Boss One, Squadron Commander Colonel Robert Hoffman, "Air Boss, Apollo 11. Everyone is okay inside. Our checklist is complete. Awaiting swimmers." Collins commented, "Houston stayed off the air and we pretty much stayed off the air except to speak when spoken to."

Waiting for the navy frogmen to arrive the three astronauts sat in silence, each trying to quell any signs of seasickness, each with their own thoughts of what was going to happen after the mission.

Commander Donald Jones, pilot of the recovery helicopter code named Swim Two, dropped three frogmen into the sea and stood by with the basket to pick up the astronauts.

Frogman Lieutenant Clancy Hatleberg opened the hatch and tossed the biological isolation garments into the hatch.

With the arrival of the Biological Isolation Garment (BIGs) the astronauts climbed into them in the lower equipment bay, Armstrong first,

Columbia's splashdown position is plotted (at left) in the Recovery Room in Building 30 for display on the large projection screen (at right). Screenshot from NASA 16mm footage.

followed by Collins and Aldrin in the right-hand seat, and that was the order they climbed out of the hatch. After some trouble closing the hatch, the swimmer started scrubbing the spacecraft down with Betadyne, while the astronauts sprayed each other down with Sodium Hypochlorite.

Armstrong was winched up first, followed by Collins then Aldrin. Collins felt strange when he first stood up in the helicopter – tired and light-headed. His body seemed heavy, especially his legs because the blood was pooling in his lower body.

In Houston, Mission Control was flowing with excited people waving flags and smoking the traditional splashdown cigars, while a big television screen displayed a picture of Columbia bobbing about in the Pacific Ocean and another flashed up,

"Task accomplished….. July 1969."

The Apollo 11 crewmen in their BIGs prior to being winched to the helicopter.
NASA photo S69-21698, courtesy of Kipp Teague's Apollo Image Gallery.

A box of cigars is opened in Mission Control, and US flags are distributed in preparation for Recovery celebrations.

Screenshot from NASA 16mm footage.

Mission Control went wild with euphoria once the astronauts were safely on board the USS Hornet and their responsibility was over. It was especially satisfying to have met their President's deadline.

At Honeysuckle Creek it was just a happy ending and going off to a free weekend with a splashdown party to come later.

Some of the key people who made Apollo 11 a success: From left –

- Robert Gilruth (MSC Director),
- Eberhard Rees (MSFC Deputy Director),
- Christopher C. Kraft (MSC Deputy Director),
- Gen. Sam Phillips (Director of the Apollo Program),
- George M. Low (Manager of the Apollo Spacecraft Program Office)

NASA photo S-69-44017. With thanks to Kathleen Phillips Esposito.

NASA photo S-69-44027. With thanks to Kathleen Phillips Esposito.

From left –

- Cliff Charlesworth (Flight Director, Green Team),
- Glynn Lunney (Flight Director, Black Team),
- Gene Kranz (Flight Director, White Team),
- Christopher C. Kraft (Director Flight Operations),
- George E. Mueller (Associate Director for Manned Space Flight),
- Robert Gilruth (MSC Director),
- George M. Low (Manager of the Apollo Spacecraft Program Office),
- Charles W. Mathews (Dep. Assoc. Administrator, OMSF; former head of Gemini Program).

GMD044A
SS DSDC HAMC HSRA HNET HPSR HFOS
DE HMSC 044
24/1543Z
SUSDUPE
TO ALL NETWORK PERSONNEL

CONGRATULATIONS AND THANKS FOR YOUR OUTSTANDING SUPPORT DURING APOLLO 11. THE ACHIEVEMENT OF OUR GOAL OF LANDING MEN ON THE MOON AND SAFELY RETURNING THEM COULD NOT HAVE BEEN ACCOMPLISHED EXCEPT FOR YOUR EFFORTS. EACH OF YOU SHARE IN THIS ACCOMPLISHMENT. THANKS AGAIN FOR A JOB WELL DONE.

SIGNED: DR. R. GILRUTH DIRECTOR MSC
G. M. LOW APOLLO PROGRAM MANAGER
C. C. KRAFT DIRECTOR FLIGHT OPERATIONS
C. E. CHARLESWORTH APOLLO 11 FLIGHT DIRECTOR

24/1547Z JUL HMSC

1969 JUL 24 17 20
GMD041A
NN AHSK ACRO GACN GANG GBDA GCAL GETC GGYM GGBM GMIL GTEX GUPA HNET LCYI LMAD LTAN MVAN MRED MMER MHTV PHAW PGWM
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FM NOM
TO ALL/STADIR SHIP REP M&O SOM M&O PERSONNEL

OPN NCG-725
THERE CAN BE NO DOUBT IN ANYONES' MIND THAT ALL OF YOU COMPRISE "THE GREATEST TRACKING NETWORK IN THE WORLD". YOUR PERFORMANCE WAS MAGNIFICENT. WE HERE IN THE MSFNOC, AND I AM SURE THE ENTIRE NASA ORGANIZATION, WISH TO EXPRESS OUR THANKS AND CONGRATULATIONS FOR A JOB EXPERTLY DONE. YOUR "CAN DO" ATTITUDE IS REFLECTED IN THE OVERALL SUCCESS OF THE FIRST MANNED LUNAR LANDING MISSION. WE ARE PROUD TO HAVE BEEN A SMALL PART OF YOUR OUTSTANDING EFFORT AND OUR ATTITUDE HERE IS "BRING ON THE PLANETS: THE MSFN CAN SUPPORT".

24/1631Z JUL GCEN

Congratulatory TWXs were sent to "All Network Personnel".

Preserved by Larry Haug, scanned by Bill Wood.

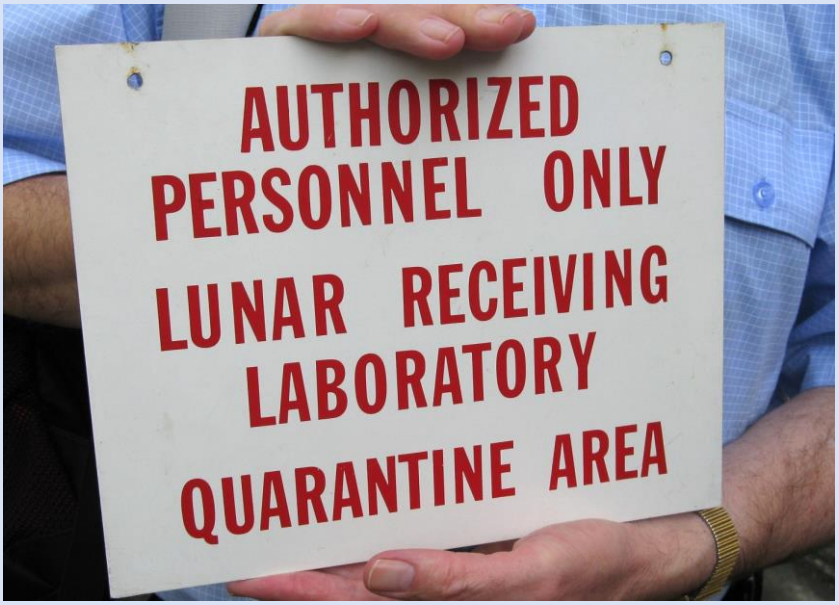
Columbia had just travelled 1,534,832 kilometres in 8 days, 3 hours 18 minutes and 35 seconds. Gathered around the landing point to greet the three intrepid space travellers were 9,000 men in 9 ships and fifty-four aircraft, spearheaded by the aircraft carrier USS Hornet.

Isolation in the Lunar Receiving Laboratory

The astronauts were placed in quarantine in the Lunar Receiving Laboratory for 11 days.

The Apollo 11 crew (Collins, Aldrin, Armstrong) relax in the quarantine van.

NASA photo KSC-69PC-485, courtesy of Kipp Teague's Apollo Image Gallery. Research: Jay Hanks.



This sign hung outside the LRL at MSC Houston.

Photo: Colin Mackellar / John Sarkissian.

Released from the Lab they were swept up in a frenzy of welcome back celebrations.

Before setting off on a trip around the world, New York showered them with ticker tape, Chicago blasted off fireworks, and Los Angeles fed them with a superb dinner at a White House state occasion where they were toasted by 1,400 guests which included the President of the United States and diplomats from 88 countries, 44 of the 50 state governors and the greatest collection of aerospace pioneers gathered under one roof. One of the pioneers was Grover Loening, the factory manager for the Wright Brothers, who saw it all in a single lifetime from Kitty Hawk to Tranquillity Base on the Moon.

New York welcomes the Apollo 11 crew with a ticker tape parade on August 13th, 1969.

Courtesy of Kipp Teague's Apollo Image Gallery.

The astronauts in Sydney, towards the end of their world trip.

Buzz Aldrin summed the trip up with, "The footprints on the Moon are a true symbol of the human spirit… they show we can do what we want to do, what we must do, and what we will do…"

Referring to the plaque left behind on the LM, Neil Armstrong added, "I hope that some wayward stranger in the third millennia may read it and say, 'This is where it all began.' It can be a beginning of a new era when man begins to understand his Universe and man begins to truly understand himself."

Tracking and Communications Summary

From our point of view communications were very good during this mission. Any breaks in transmission from the CSM were mainly due to the high-gain antenna alignment during spacecraft manoeuvring, fixed either by a spacecraft attitude change or switching to the omni antennas.

The real test came when the astronauts were on the Moon's surface. The high-gain antenna on the stationary LM had no problems finding the Earth, and the telemetry from the EMU's (Extravehicular Mobility Unit) was solid as a rock throughout the EVA. The signals from the EMU's worked well even when the astronauts were out of sight of the EVA antenna on top of the LM due to good reflections from the lunar surface.

However, there were a few problems with Buzz Aldrin's voice. Vox (voice operated transmission) was used all the time to keep the astronaut's hands free. The EMU vox was very fast, but the series vox in the LM's S-Band transmitter had not been set to maximum sensitivity, which caused some breaks in Aldrin's voice transmissions. He also had some problems with the placement of his microphones inside the helmet. It appears to have been displaced as he moved about. Mission Control had to ask him to talk into his microphone a couple of times. In the thin pure oxygen atmosphere and lower ambient pressure of about 3.5 psi inside the suits sound did not travel so well. It did not help that Aldrin spoke with a jerkiness and had a more inflected voice than Armstrong, which added to his vox's difficulties.

One exchange between Capcom Charlie Duke and Aldrin went like this:

> *"Buzz, this is Houston. You're cutting out on the end of your transmissions. Can you speak a little more forward into your microphone? Over"*
>
> *"Roger – I'll try that."*
>
> *"Beautiful."*
>
> *"Now, I had that one inside my mouth that time."*
>
> *"It sounded a little wet!"*

Other minor problems were the distant echoing of sentences of the voice relay from Earth, particularly during Nixon's speech and the noise caused by the MSFN VOGAA (a noise suppression device [voice-operated gain-adjust device]). The LM crew complained it sounded like "somebody banging chairs around the back of the room…." and was disabled.

Communications between the orbiting CSM and the LM on the lunar surface had its own problems. Although the two spacecraft were in sight of each other for up to 23 minutes as the CSM passed over the landing site, VHF inter-vehicle frequencies only allowed about 8 minutes of contact each pass. Outside the 8 minutes in sight of the LM, Collins communicated with it via an S-Band relay through the tracking stations on Earth. This relay had a round-trip delay of 3 seconds so a lot of the time a one-way S-Band link was set up for Collins to hear what was going on, but he could not talk directly to the astronauts on the surface.

The planning of the Apollo 11 mission – The Flight Plan

In all the hype surrounding the Apollo missions nobody seems to have commented on the stunning accuracy of the pre-mission planning – all of us were following an official Flight Plan which laid down every step of the mission. Armstrong's decision to come out early, and the amazing result, when the Eagle coupled up with Columbia just three minutes behind the Flight Plan, and at the very end Columbia dropped into the Atlantic Ocean a mere 42 seconds behind the revised Flight Plan, but only 24 seconds ahead of the original Flight Plan published on 1 July 1969!!

I spoke to Rod Rose, Chairman of the Mission Planning and Analysis Division of Flight Operations, about his phenomenal accuracy in planning such a complex mission that had never been done before This is what he said to me,

> "There was a big build-up of effort by many people in several organisations to obtain a very accurate celestial model. Then we worked out the bugs across the window of opportunity and honed the Earth/Moon relationship. Next, we had very good real time tracking and navigation, and we designed the mission trajectory profile with allowances for tweaking

burns – if needed. We would then make a small RCS (Reaction Control rocket System) correction early, never allowing the mid-course delta-V to build up. The same philosophy was applied on the way back from the Moon."

The following table lists the updated Flight Plan compared to the actual execution, as published in the NASA Manned Spacecraft Center Roundup newspaper, Volume 8, No 21, dated 8 August 1969, page 3. Main events are highlighted in yellow.

GET = Ground Elapsed Time; i.e. time from launch.

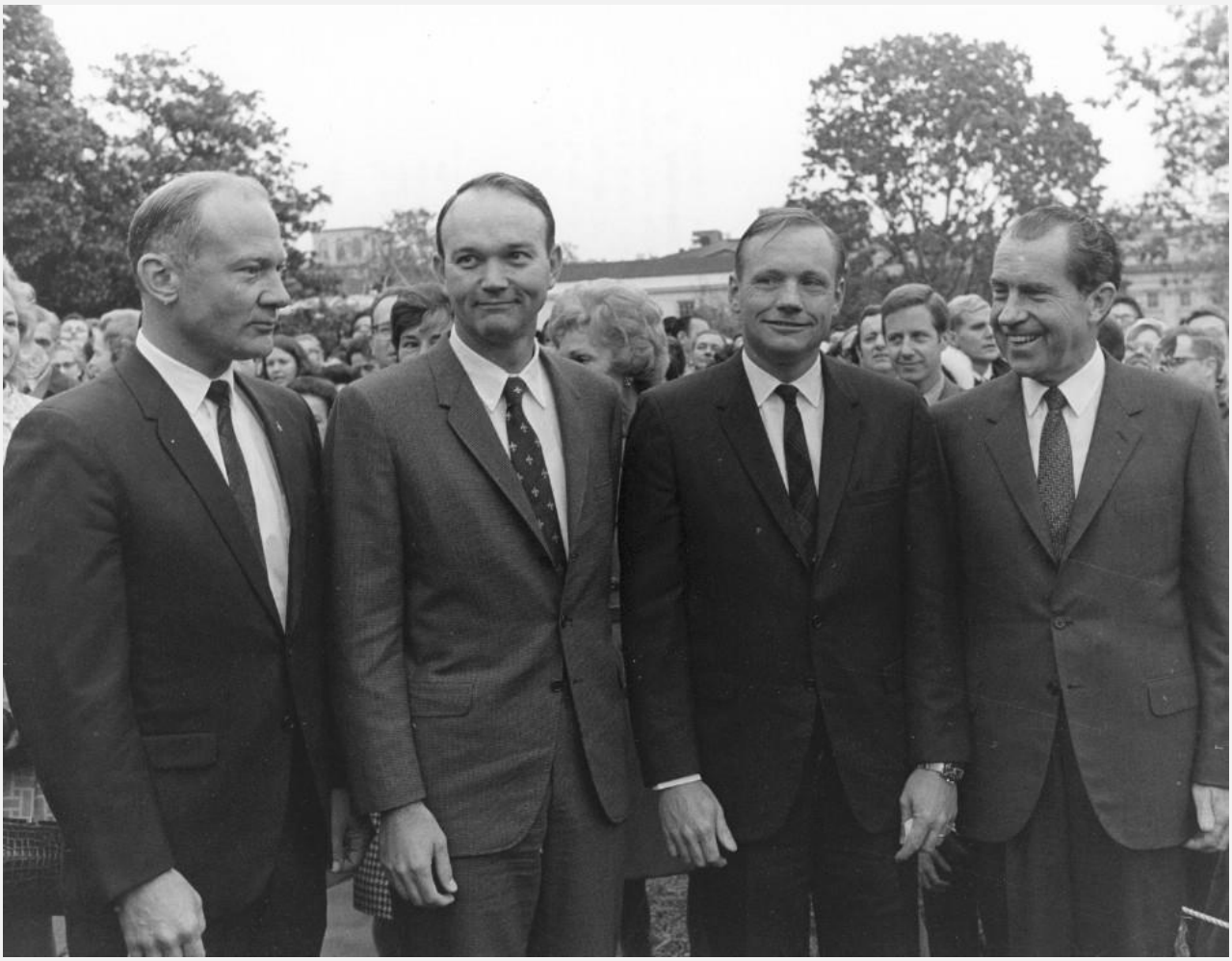
Event	GET Planned	GET Actual
LiftOff	00:00:00	00:00:00.6
S-1C stage cut-off	00:02:40.4	00:02:41.7
S-II engine ignition	00:02:41.8	00:02:43
S-II engine cut-off	00:09:11	00:09:08.3
S-IVB engine ignition	00:09:15	00::09:12.2
S-IVB engine cut-off	00:11:39	00:11:39.2
Insertion Earth orbit	00:11:48.8	00:11:49.3
Translunar Injection	02:50:13.4	02:50:13.0
SIVB CSM separation	03:15:03	03:17:04.6
Midcourse correction #1	11:30:00	Unnecessary
Midcourse correction #2	26:44:58	26:44:58.8
Midcourse correction #3	53:55:00	Unnecessary
Midcourse correction #4	70:55:00	Unnecessary
Lunar orbit insertion	75:49:00	75:49:50.5
LM/CSM separation	100:39:50	100:39:51
Descent Orbit Insertion	101:36:14	101:36:15
Powered Descent initiation	102:33:04	102:33:05
Lunar landing	102:45:05	102:45:39
Lunar crew egress	107:59:00	109:07:36
Lunar crew ingress	111:47:00	111:39:00
Lunar Lift Off	124:21:00	124:22:00
Second docking	128:00:00	128:03:00
LM jettison	130:30:00	130:09:00
Transearth Injection	135:23:41	135:23:42
Midcourse correction #5	150:29:54	150:29:56
Midcourse correction #6	172:00:00	Unnecessary
Midcourse correction #7	192:06:00	Unnecessary
Entry Interface	195:03:07	195:03:07
Main chute deployment	195:12:56	195:12:57
Splashdown	195:17:53	195:18:35

Click the image for the table in PDF format.

With the safe return of Apollo 11, the Apollo team had met President Kennedy's deadline. The whole concept of the Apollo mission had now been proved to work with outstanding success, which meant that exploring the Moon was now a reality, and the remaining Apollo missions could concentrate on the scientific side of the flights.

After Apollo 11, four "H" missions were planned, each of which would be able to carry a complete Apollo Lunar Surface Experiments Package (ALSEP), could support two periods of surface activity by the astronauts, and would be targeted for a smaller, more accurate landing zone than the first mission. On the later "H" missions, engineers expected to be able to land within a 1-kilometre circle. After the "H" missions, six "J" missions would be flown, but it wasn't long before budget restrictions chopped into this ambitious program. It is interesting to note that the magazine Aviation Week & Space Technology dated 4 August 1969 was still listing Apollos 18, 19, and 20, complete with landing latitude and longitude coordinates. A landing in the crater Copernicus was planned to be the Grand Finale to the Apollo Program with Apollo 20, as the walls of the crater exposed almost 6 kilometres of vertical lunar crust. One fanciful proposal was to use flying vehicles to explore terraces on the surrounding cliffs.

Now that would have been a spectacular finale.



The three astronauts with President Nixon after the flight.

ACRONYMS USED IN THE TEXT

The following table explains acronyms used:

ABC – Australian Broadcasting Corporation.

ACN – Ascension Island Tracking Station in the southeast Atlantic Ocean.

AEST – Australian Eastern Standard Time.

ALS – Apollo Landing Site.

ALSJ – The Apollo Lunar Surface Journal website – every word spoken on the lunar surface.

AOS – Acquisition Of Signal from the spacecraft (the downlink).

CADFISS – Computation And Data Flow Integrated Sub System test.

Capcom – Capsule Communicator, the voice of Mission Control, always an astronaut.

CM – Command Module.

CRO – Carnarvon Tracking Station, WA.

CSM – Command and Service Module.

DOI – Descent Orbit Insertion.

EASEP – Early Apollo Scientific Experiments Package, Equipment left behind by the astronauts to measure physical characteristics of the Moon.

EVA – Extra Vehicular Activity, or a space walk outside the spacecraft or on the lunar surface.

GDS – Goldstone Tracking Station in California.

GET – Mission Ground Elapsed Time, time in hours/minutes/seconds from launch.

GWM – Guam Tracking Station in the northwest Pacific Ocean.

HSK – Honeysuckle Creek Tracking Station, Canberra, Australia.

HSKX – Canberra Deep Space Communications Complex at Tidbinbilla, also called the Wing.

IU – Instrumentation Unit, electronic system part of the Saturn IVB rocket.

LM – Lunar Module.

LOI – Lunar Orbit Insertion.

LOS – LOs of Signal, Loss of the downlink signal from the spacecraft.

MAD – Madrid Tracking Station, Spain.

MESA – Modular Equipment Stowage Assembly, part of the LM Descent Stage.

MOCR – Mission Operations Control Room, Houston

MSFN – Manned Space Flight Network. The tracking stations around the world.

NET-1 – Phone line between Mission Control Capcom and astronauts in spacecraft.

OMNI – Multiple omnidirectional antennas around the Command & Service Module and Lunar Module.

OTC – Australian Overseas Telecommunications Commission.

PDI – Powered Descent Initiation.

PGNCS – Primary Guidance, Navigation and Control System.

PKS – Parkes, 64 metre radio telescope at Parkes in New South Wales, Australia.

PLSS – Portable Life Support System – the backpacks supplying astronauts' physical needs.

PMG – Australian Post Master General's Department, now Telstra

PTC – Passive Thermal Control – spinning the spacecraft to even temperatures around it.

RCS – CSM Reaction Control System for controlling the attitude of the spacecraft.

SM – Service Module

SRT – Site Readiness Test. Tracking station equipment tests before each group of passes.

TEC – Trans Earth Coast – the voyage back to Earth.

TEI – Trans Earth Injection – the rocket motor burn to send Apollo 11 back to Earth.

TLC – Trans Lunar Coast – the voyage out to the Moon.

TLI – Trans Lunar Injection – the rocket motor burn to send Apollo 11 off to the Moon.

UPLINK – The signal sent from the tracking station up to the spacecraft.

USCDT – US Central Daylight-Saving Time, also spacecraft time.

USEDT – US Eastern Daylight-saving Time.

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Aldrin, Buzz – Lunar Module Pilot

Armstrong, Neil – Mission Commander

Blake, Alan – Transmitter Engineer, Tidbinbilla Tracking Station

Bostick, Jerry – Flight Dynamics Officer (FIDO), Mission Control Center

Duke, Charlie – Capcom for landing, Mission Control Center

Gallegos, Kevin – Demodulator technician, Honeysuckle Creek

Gray, Don – Station Director at Tidbinbilla Tracking Station

Gray, Trevor – PMG (now Telstra) technician on television links from Honeysuckle Creek.

Haise, Fred – Back up Lunar Module pilot

Kraft, Chris – Director of Flight Operations, Mission Control Center, Houston

Kranz, Gene – Flight Director, White Team, Mission Control Center, Houston

Liebergot, Sy – EECOM, Mission Control Center

Mason, Neil 'Fox' – Parkes antenna driver

Oates, Paul – Deputy Director, Carnarvon Tracking Station

Reid, Tom – Station Director, Honeysuckle Creek Tracking Station

Renouard, Ed von – Television technician, Honeysuckle Creek

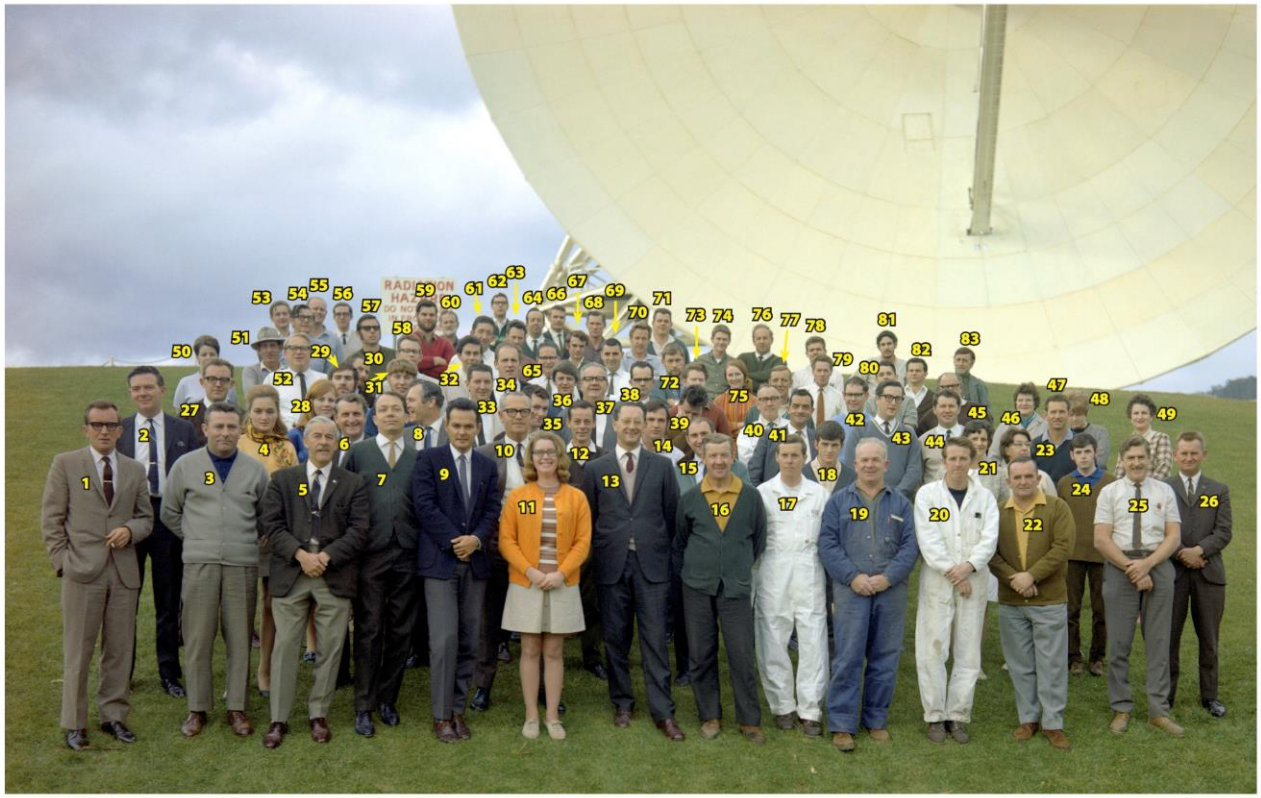
Rose, Rod – Chairman of the Planning and Analysis Division of Flight Operations, Houston.

Saxon, John – Operations supervisor, Honeysuckle Creek

Wood, Bill – USB Lead Engineer, Goldstone Tracking Station.

Essay by Hamish Lindsay.
Images, illustrations and captions by Hamish Lindsay and Colin Mackellar.
Audio files sourced & edited by Colin Mackellar.
PDF formatted by Glen Nagle.

(Most of) the Honeysuckle Creek post-Apollo-11 team



1. Tom Reid
2. Mike Dinn
3. Martin Geasley
4. Dianne McMinn
5. Ken Lee
6. Frank Campbell
7. Mike Evenett
8. Laurie Turner
9. Bill Kempees
10. Bruce Hamilton
11. Gillian Morris
12. Alan Foster
13. Tony Cobden
14. Graham Fraser
15. Len Litherland
16. George Hardy
17. Ernie Cummins
18. Rod Lindrea
19. Paddy Sheehy
20. Ian Smith
21. Lettie Megee
22. Roy Belchambers
23. Dini Quaedvlieg
24. Shaun McGrail
25. Trevor Conyard
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27. Peter Kent
28. Diane Gallea
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32. Eric Stallard
33. Les Hughes
34. John Mitchell
35. Mike Linney
36. Dave Ralph
37. Dick Bamford
38. Nevil Eyre
39. Paul Mullen
40. Tom Wilson
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43. Bernard Smith
44. Jim Kirkpatrick
45. Horrie Clissold
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47. Ted Burt
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49. Judy Wise
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56. Bryan Sullivan
57. Frank Hain
58. Geoff Seymour
59. Ken Sheridan
60. Keith Hiscock
61. Terry Lloyd
62. Ron Chivers
63. Henry Gilkens
64. Bob Blunt
65. Ed von Renouard
66. John McLeod
67. Fred Hill Jr. (?)
68. Brian Bell
69. Jim Hanlon
70. Jerry Bissicks
71. Tony Van der Putten
72. Ian Mackay
73. Col Cochran
74. Kevin Gallegos
75. Paula Denning
76. Tony Salvage
77. Bob Dawes
78. Jeff Day
79. Jim (Dutchy) Holland
80. Ross Barnes
81. Col Power
82. Kevin Crabbe
83. Fred Hill Sr.

Most (but not all) of the Honeysuckle team for Apollo 11 – photo taken soon after the mission.

Not in photo: Hamish Lindsay (behind the camera!), John Saxon, Ian Grant, Andrew Tupalski, Tony Gerada, Vic Burman, and many others (we'll add those names when possible).

With thanks to John Saxon, Mike Dinn, Bryan Sullivan, Ken Sheridan, Martin Geasley, Paula Denning, Tony Gerada, Ian Mackay, and others.

Photo: Hamish Lindsay. Scan of 4x5 inch negative, image processing and key: Colin Mackellar, July 2022. honeysucklecreek.net

v. 2.1

Larger annotated version here, and the photograph only.


APOLLO 11

ABOUT THE AUTHOR

Hamish Lindsay (1937-2022) worked at the Muchea, Carnarvon and Honeysuckle Creek space tracking stations between 1963 and 1981.

He wrote many essays on the history of human spaceflight, and was the author of the book, Tracking Apollo to the Moon.