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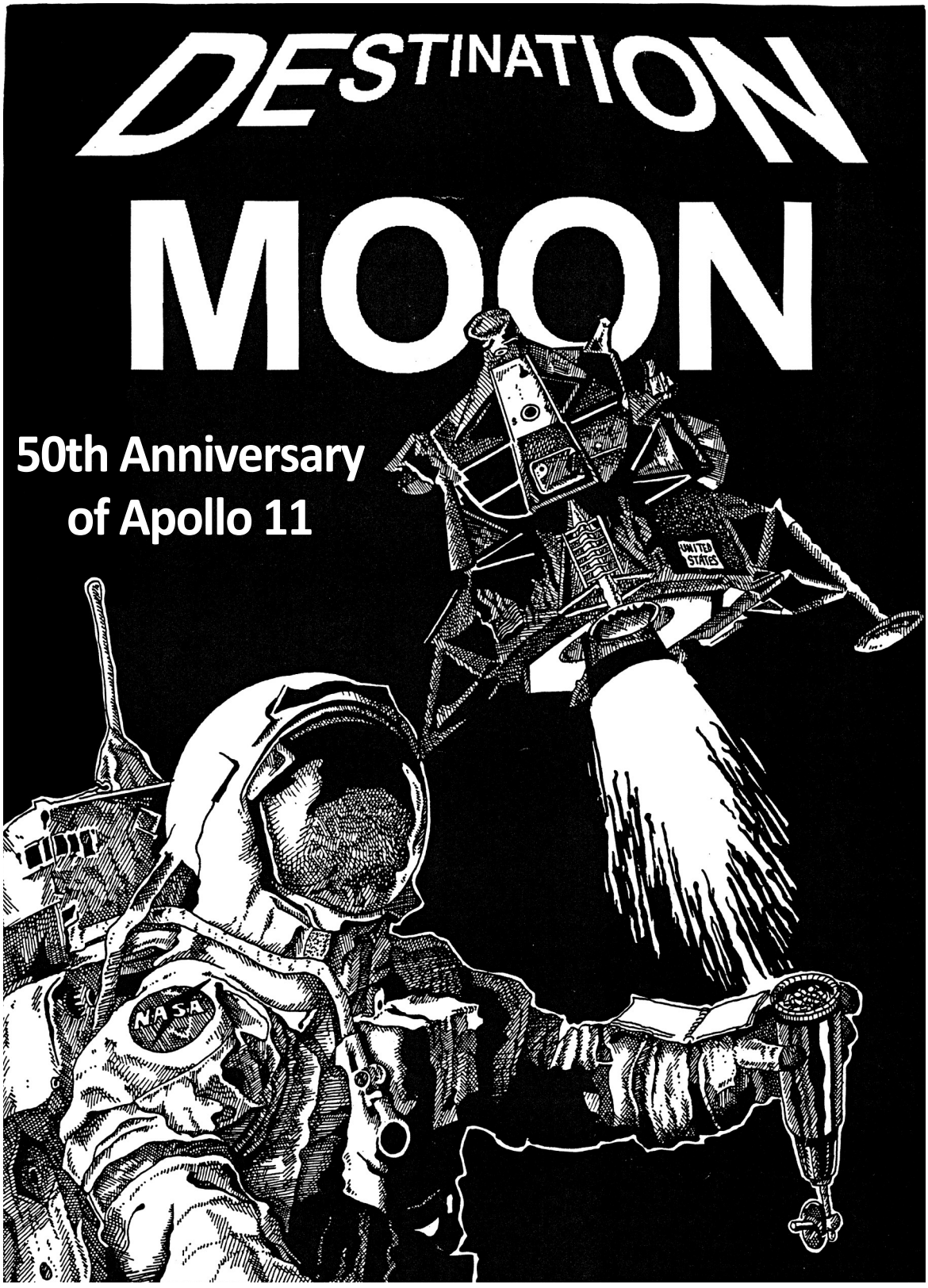

Artwork by Peter Grego for MSS

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space news roundup

NASA Selects First Commercial Moon Landing Services for Artemis Program

NASA has selected three commercial Moon landing service providers that will deliver science and technology payloads under Commercial Lunar Payload Services (CLPS) as part of the Artemis program. Each commercial lander will carry NASA-provided payloads that will conduct science investigations and demonstrate advanced technologies on the lunar surface, paving the way for NASA astronauts to land on the lunar surface by 2024.

"Our selection of these U.S. commercial landing service providers represents America's return to the Moon's surface for the first time in decades, and it's a huge step forward for our Artemis lunar exploration plans," said NASA Administrator Jim Bridenstine. "Next year, our initial science and technology research will be on the lunar surface, which will help support sending the first woman and the next man to the Moon in five years. Investing in these commercial landing services also is another strong step to build a commercial space economy beyond low-Earth orbit."

As part of their submissions, each partner proposed flying specific NASA instruments to the lunar surface. By the end of the summer, NASA will determine which payloads will fly on each flight. The potential payloads include instruments that will conduct new lunar science, pinpoint lander position, measure the lunar radiation environment, assess how lander and astronaut activity affects the Moon, and assist with navigation precision, among other capabilities.

The selections are:

- Astrobotic of Pittsburgh has been awarded $79.5 million and has proposed to fly as many as 14 payloads to Lacus Mortis, a large crater on the near side of the Moon, by July 2021.
- Intuitive Machines of Houston has been awarded $77 million. The company has proposed to fly as many as five payloads to Oceanus Procellarum, a scientifically intriguing dark spot on the Moon, by July 2021.
- Orbit Beyond of Edison, New Jersey, has been awarded $97 million and has proposed to fly as many as four payloads to Mare Imbrium, a lava plain in one of the Moon's craters, by September 2020.

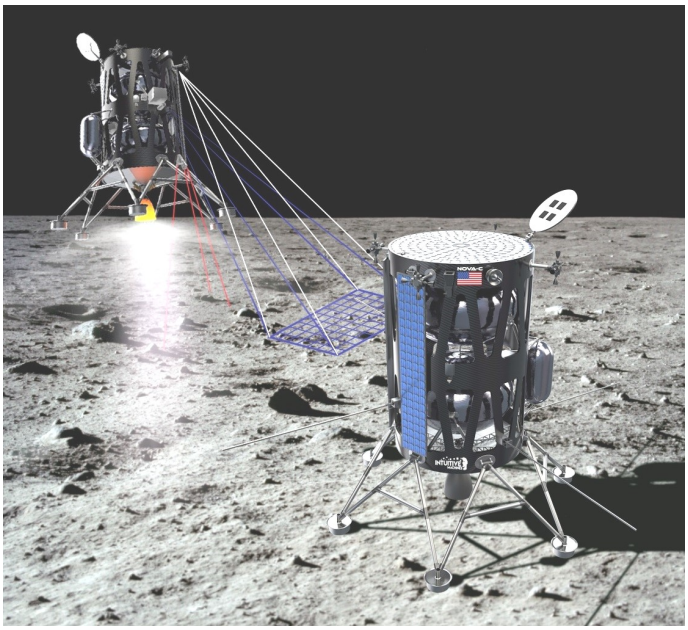
"These landers are just the beginning of exciting commercial partnerships that will bring us closer to solving the many scientific mysteries of our Moon, our solar system, and beyond," said Thomas Zurbuchen, associate administrator of NASA's Science Mission Directorate in Washington. "What we learn will not only change our view of the universe, but also prepare our human missions to the Moon and eventually Mars."

Each partner is providing end-to-end commercial payload delivery services to NASA, including payload integration and operations, launch from Earth and landing on the surface of the Moon. These early missions will enable important technology demonstrations that will inform the development of future landers and other exploration systems needed for humans to return to the lunar surface. They also will help prepare the agency to send astronauts to explore Mars.

"This announcement starts a significant step in NASA's collaboration with our commercial partners," said Chris Culbert, CLPS program manager at NASA's Johnson Space Center in Houston. "NASA is committed to working with industry to enable the next round of lunar exploration. The companies we have selected represent a diverse community of exciting small American companies, each with their own unique, innovative approach to getting to the Moon. We look forward to working with them to have our payloads delivered and opening the door for returning humans to the Moon."

As additional science, technology demonstration, and human exploration requirements for payloads develop, a request for task order bids will go to all current CLPS contractors. All nine companies initially selected in November 2018 for CLPS will be eligible to bid on subsequent task orders.

Charged with returning astronauts to the Moon within five years, NASA's Artemis lunar exploration plans are based on a two-phase approach: the first is focused on speed – landing astronauts on the Moon by 2024 – while the second will establish a sustained human presence on and around the Moon by 2028. We will use what we learn on the Moon to prepare to send astronauts to Mars.



Intuitive Machines of Houston has proposed to fly as many as five payloads to a scientifically intriguing dark spot on the Moon.

Credits: Intuitive Machines

NASA Reflects on Legacy of LRO as Moon-Orbiting Mission Reaches 10-Year Anniversary

5:32 p.m. Eastern Time on 18 June 2019, marks 10 years since the launch of the Lunar Reconnaissance Orbiter (LRO). Its contributions to the fields of lunar science and exploration are unmatched: it has provided the largest volume of data ever collected by a planetary science mission.

The diverse suite of instruments aboard LRO include a laser altimeter that fires pulses of light about 28 times per second, creating one of the most accurate topographic maps of any celestial body. LRO measured the coldest known temperatures in the solar system at the Moon's poles. Observations of tectonic features across the lunar surface indicated the Moon's gradual shrinkage — LRO showed us not a dead but rather a dynamic and intriguing Moon.

LRO's original mission duration was supposed to be one to two years, not 10. "We've just submitted our fourth extended mission proposal," said Noah Petro, project scientist of LRO at NASA's Goddard Space Flight Center in Greenbelt, Maryland. "With the national focus on the Moon as part of NASA's Moon to Mars strategy, the data from LRO has been instrumental in Artemis planning and the mission will continue to be a major player going forward in finding more landing sites for humans and robotic explorers. The work that we're doing is meaningful to the science community, to NASA and to the world."

The Allure of the Moon

In the months leading up to its launch, LRO received submissions of over a million names as part of an initiative to involve the public in NASA's return to the Moon. The names, encoded on a microchip, launched with LRO. "It gave people a sense of not just belonging but also of being part of a mission," Petro said.

Why does Earth's largest satellite have such a widespread impact upon human imaginations? Beyond the invaluable science and data that LRO gave and continues to give to benefit the onward march of scientific advancement, LRO personifies the investigation of all that is utterly extraordinary about the Moon.

As part of NASA's 60th anniversary celebration last year, the National Symphony Orchestra played Claude Debussy's "Clair de Lune" at the Kennedy Center in Washington set to projections of digital images of a lunar day. Science visualizer Ernie Wright, also of Goddard, created this breathtaking view of the Moon's landscape entirely with LRO data.

The stunning video produced a palpable reaction among those who were at the live performance. "People came up to me during the intermission and asked if I was the photographer," Wright said. "They didn't understand completely what I'd made, but they had an emotional reaction to the visual and the way it was combined with the music."

Wright has been fascinated by the Moon since he saw, live on television, the first humans to step foot on the Moon with the Apollo 11 mission. His connection to the Moon persevered for decades. "I feel especially lucky to be specifically involved with LRO and with data rendering of the Moon because the lunar landing was my first memory of a major space event," he said. A return to the Moon could inspire a new generation of people motivated, like Ernie Wright, by their specific lunar connection.

LRO's Figurative Shortening of the Lunar Distance

LRO is a major source of information about the moon for NASA. "When they want someone to talk about the Moon, they call the LRO team," Petro said. "LRO's continuation is a direct result of NASA's interest in the Moon."

NASA is obviously not the only entity with an interest in the Moon — yet one particular factor seems to shape humanity's fascination.

"The Moon is very accessible," said Molly Wasser, planetary science and LRO digital media lead from Goddard. "Anyone can see it, no matter where you are — from the brightest cities to the most remote communities. It's a way to introduce children to space since little kids can see it and observe it changing over time. There's something very romantic about it. Everyone loves the Moon."

The rise of social media over the span of LRO's lifetime further satiates the public desire for lunar information, but images get the most attention. Having collected over a petabyte (one billion megabytes) of data, LRO has millions of photos of stark geological features lit sharply by unfiltered sunlight. "That content gets the most traction," Wasser said.

The Moon is visible and it is the largest object in Earth's night sky. "The Moon has that immediacy," Petro said. "There's a connection that people can have which puts it at the forefront of our consciousness." Even if they are unaware of the mission, LRO brings the Moon to humans in detail precise enough to see the sites of previous lunar missions — a feat beyond impossible for the naked eye.

Apollo, LRO and Artemis

The Moon's scientific value is not to be understated. The history of the solar system's evolution is almost indelibly pounded into the lunar surface, providing data over billions of years that mirrors Earth's history. The Moon exists without the protective effects of an atmosphere or the erasure of geological history as rocks cycle through the processes of plate tectonics.

"We use the Moon as a template for understanding how any solid object in the solar system formed, and by extension, solid objects anywhere in the universe," Petro said. "There's an important reason why we study the Moon — it's not only the Moon for the Moon's sake. It's an extension of the Earth."

Observation of the Moon long predates LRO and Apollo. "So many people don't notice it or think anything of it," Petro said. "But the Moon is a part of our consciousness." The Moon, however, isn't merely ingrained into cultural memory: it is also part of humanity's future.

NASA recently announced its commitment to return to the Moon by 2024 with the Artemis program. Named for the mythological Greek Moon goddess and twin of Apollo, Artemis carries humanity back to our largest satellite — this time, for good — before we launch to Mars and to the unexplored beyond.

NASA Goddard Spaceflight Center
https://www.nasa.gov/goddard

NEIL, BUZZ & MIKE

How Did They Get to Fly Apollo 11?

By Rob Wood

A cool calculating ex-navy carrier pilot who became a top NASA test-pilot, an articulate super fit graduate of West Point with a family history of military service, and a pilot-engineer with a doctorate in astronautics whose dissertation was on manned orbital rendezvous. Michael Collins in his autobiography 'Carrying the Fire' wrote that *"Neil was far and away the most experienced test pilot among the astronauts, and Buzz the most learned, especially when it came to rendezvous."* Walter Cunningham in his book 'The All-American Boys' said of *Collins "Mike may have been the best-conditioned of the Apollo Group,"* in a reference to NASA's third astronaut selection (1963). Cunningham added that Collins was *"Hard as nails."*

Neil Armstrong, Michael Collins and Buzz Aldrin seem obvious choices for the first lunar landing mission and you would think that they were specially selected for the flight. But they were not. If everything had gone according to plan it is unlikely that any of them would have been on the mission. So how did they get to fly on Apollo 11?

The story begins with the first group of NASA astronauts, 'The Mercury 7'. The astronauts were announced to the world at a press conference at 14:00hrs local time on Thursday 9 April 1959. About 150 reporters and cameramen had gathered in the auditorium at NASA Headquarters in Washington DC. Thomas Glennan, NASA's first Administrator, opened the briefing by introducing *"the nation's Mercury astronauts."* They were sat in alphabetical order on the stage: Scott Carpenter, Gordon Cooper, John Glenn, Gus Grissom, Walter Schirra, Alan Shepard and Donald 'Deke' Slayton.

As the story unfolds we will see that NASA intended a Mercury 7 astronaut to be the first human to walk on the Moon but events, and perhaps impressions about some of the contenders, excluded that possibility. It was however a Mercury 7 astronaut that chose the first human to walk on the Moon.

Deke Slayton was assigned to fly the fourth manned spaceflight of the Mercury Programme when on 15 March 1962 he was told that he was off the flight. A heart condition called idiopathic atrial fibrillation (an erratic heart rate) had led to his active flight status being rescinded. He was assigned as Coordinator of Astronaut Activities with responsibility for directing the newly formed Astronaut Office. Unofficially, he held the title of 'Chief Astronaut' and it was his job to assign astronauts to missions and be involved in the selection of new astronauts. One of Slayton's earliest duties as Chief Astronaut was chairing the selection board for NASA's second group of astronauts.

On 17 September 1962, NASA named nine new astronauts including Neil Armstrong. The full list was: Armstrong, Frank Borman, Charles Conrad, James Lovell, James McDivitt, Elliot See, Thomas Stafford, Edward White and John Young. Around this time, Deke Slayton was also delving into the depths of crew assignment for the first time. He selected fellow Mercury 7 astronaut Gordon Cooper to fly what would turn out to be the last Mercury manned flight. There had been plans to fly a seventh manned mission with Alan Shepard as the pilot but with the US second generation manned spacecraft, Gemini, a much more capable spacecraft, shortly to fly, another Mercury manned mission was deemed unnecessary.

On 14 October 1963, NASA named a third group of astronauts. The fourteen new guys included United States Air Force (USAF) Major Edwin 'Buzz' Aldrin and USAF Captain Michael Collins. The full group was: Aldrin, William Anders, Charles Bassett, Alan Bean, Eugene Cernan, Roger Chaffee, Collins, Walter Cunningham, Donn Eisele, Theodore Freeman, Richard Gordon, Rusty Schweickart, David Scott and Clifton Williams. With the selection of the third group, we now have all the astronaut players for our story.

The same month that NASA's third group of astronauts were chosen, Deke Slayton was also named Assistant Director of Flight Crew Operations, a new office with responsibility for directing the Astronaut Office, Aircraft Operations Office and Flight Crew Support Division. He remained head of the Astronaut Office and Chief Astronaut (three years later he was promoted to Director of Flight Crew Operations).

Deke Slayton's time as head of the Astronaut Office and Chief Astronaut did not last for long. Another Mercury 7 astronaut, Alan Shepard, suffered from bouts of dizziness and was diagnosed with Ménière's disease, a disorder of the inner ear causing vertigo, tinnitus and hearing loss. Shepard was America's first human in space when he made the suborbital Mercury-Redstone 3 spaceflight (flew 5 May 1961). In October 1963, Shepard joined Slayton on the grounded list.

Although Alan Shepard wanted to regain his flight status that was not going to happen in short time. Deke Slayton decided he could do with some help and with NASA management agreement appointed Shepard head of the Astronaut Office and Chief Astronaut. The appointment was announced by NASA on 9 July 1964. Slayton continued to be responsible for the selection of crews but with input from Shepard. They also often solicited the opinion of their chosen crew commanders. Slayton and Shepard's choices did require approval by senior NASA management but it was rare that their selections were queried.

Prior to Alan Shepard's grounding, Deke Slayton had it in

mind to appoint Shepard as commander of the first manned Gemini mission. It was at this time Slayton developed the three mission rotation idea that would see a back-up crew skip two missions and then be prime for the third, which would be followed through to the end of the Apollo Moon landings with the odd exception. With Shepard out of the picture, Slayton had to assign several astronauts earlier than he would have done. Neil Armstrong was assigned as Command Pilot of the Gemini 5 back-up crew, which would put him in line to fly and command Gemini 8. Command experience for Armstrong in Gemini would qualify him for a command position in Apollo. If Armstrong had appeared later in the Gemini crew rota then his position in Apollo might have been after Apollo 11.

A word or two is needed on nomenclature of crew positions as these change during the time period covered by this article. For Gemini the crew positions were named as Command Pilot (CP) and Pilot (PLT). As Deke Slayton assigned the early Apollo crews, the crew positions were designated CP, Senior Pilot (SP) and PLT and are named in that order in this article. However, the titles changed when on 29 November 1966 Deke Slayton released a memorandum detailing new names – Commander (CDR), Command and Service Module Pilot (CMP) and Lunar Module Pilot (LMP). They are named in that order in this article.

Towards the end of 1965, Deke Slayton began to form the early Apollo crews and was also thinking of their potential to rotate to lunar landing crews. His initial back-up crew for the first manned Apollo mission, Apollo 1, was CP James McDivitt, SP David Scott and PLT Rusty Schweickart. He was aiming this crew for the first test flight of the Lunar Module but he also thought they were a potential lunar landing crew. Slayton did not think the prime crew for Apollo 1 needed a lot of spaceflight experience because there was no Lunar Module involved. So apart from the commander he chose two rookies to fill out the crew. Mercury 7 astronaut Gus Grissom was the CP with Donn Eisele and Roger Chaffee in the other two slots.

There was soon a change of plan when Donn Eisele injured his shoulder on a Boeing KC-135 Stratotanker zero-gravity simulator aircraft training flight. Deke Slayton was already thinking of putting Ed White on the second Apollo mission so it was simple to replace Eisele with White.

Early in 1966, Deke Slayton quietly put together the crews for the second manned Apollo flight, Apollo 2. This mission was not significantly different to the first and again Slayton could look at two rookies for the crew. He went back to the Mercury 7 astronauts for the CP and appointed Walter Schirra. His two pilots were the now recovering Donn Eisele and Walter Cunningham. The back-ups were Frank Borman, Charles Bassett and William Anders. Deke thought the latter team would make a good lunar landing crew. So the first two crews looked like this:

Apollo 1: Gus Grissom, Ed White and Roger Chaffee
Apollo 1 back-ups: James McDivitt, David Scott and Rusty Schweickart.
Apollo 2: Walter Schirra, Donn Eisele and Walter Cunningham
Apollo 2 back-ups: Frank Borman, Charles Bassett and William Anders

On 28 February 1966, the Gemini 9 prime and back-up crews were flying to the McDonnell Aircraft Corporation plant in St Louis, Missouri, from Ellington Air Force Base, Texas, to conduct training in the Gemini simulator located at McDonnell. Weather was poor with rain, snow, fog and low clouds, and on final approach for landing at Lambert Field the prime crew of Elliot See and Charles Bassett crashed their Northrop T-38 Talon jet trainer aircraft into the building where their Gemini spacecraft was being built. Both See and Bassett were killed.

The Gemini 9 spacecraft was not damaged and the accident did not result in delaying the actual spaceflight but it did result in major changes to the crews for the rest of the Gemini Programme. More importantly, for the purpose of this article, was that it had a significant effect on astronauts that became part of the crew of Apollo 11. As Deke Slayton wrote in his autobiography 'Deke', *"The accident wound up having a lot to do with who wound up landing on the Moon."*

The Gemini 9 back-ups were given the prime assignment and all the back-ups changed. The Gemini 10 back-ups of James Lovell and Buzz Aldrin moved up to back-up Gemini 9, which put them in the prime position for the last Gemini mission, Gemini 12. If Aldrin had remained as back-up for Gemini 10 than he would not have flown in space before the Apollo Programme and as Slayton explained in 'Deke', *"Without flying GT-12* [Gemini 12] *it was very unlikely that Buzz would have been in any position to be lunar module pilot on the first lunar landing attempt."*

The Gemini 10 prime crew remained the same with John Young as CP and Michael Collins as PLT. Already by this time, Deke Slayton had decided that the astronaut to be left alone in the Apollo Command Module needed to have spaceflight experience and preferably rendezvous experience. Gemini 10 (flew 18-21 July 1966) ticked these boxes for Collins. Gemini 12 (flew 11-15 November 1966) ended the flight phase of the Gemini Programme and gave Buzz Aldrin the experience in spaceflight he needed to progress on to early Apollo missions.

The loss of Charles Bassett had effects for Apollo crewing as well. Deke Slayton had to replace him on the Apollo 2 back-up crew and he assigned Thomas Stafford. William Anders was moved to back-up pilot on Gemini 11 from his back-up position on Apollo 2 and when Michael Collins completed his Gemini 10 assignment he replaced Anders as an Apollo 2 back -up. The crews now looked like:

Apollo 1: Gus Grissom, Ed White and Roger Chaffee
Apollo 1 back-ups: James McDivitt, David Scott and Rusty Schweickart.
Apollo 2: Walter Schirra, Donn Eisele and Walter Cunningham
Apollo 2 back-ups: Frank Borman, Thomas Stafford and Michael Collins

As 1966 moved on questions were asked about the need for the Apollo 2 mission. The general view was that it was an unnecessary duplication of Apollo 1. On the same day Gemini 12 splashed down the Apollo 2 crew were told their flight was cancelled. Deke Slayton shuffled the crews once again. The Apollo 1 prime crew remained Gus Grissom, Ed White and Roger Chaffee but he made their back-ups what was previously the prime crew for Apollo 2, Walter Schirra, Donn Eisele and Walter Cunningham.

Apollo 3, which was supposed to be the first test flight of the Lunar Module, now became Apollo 2 and Deke Slayton

assigned the original Apollo 1 back-up crew of James McDivitt, David Scott and Rusty Schweickart as the prime crew. For the new Apollo 3, another Lunar Module test flight, he assigned Frank Borman, Michael Collins and William Anders. Collins had received a promotion as a result of Slayton's policy of having a spaceflight experienced astronaut as the pilot of the command module and in Collins own words in his autobiography 'Carrying the Fire' *"lost right then and there his first chance to walk on the surface of the Moon."*

As 1966 drew to a close Slayton put together more crews that he saw as potential lunar landing crews: Thomas Stafford received a promotion to lead his own crew of John Young and Eugene Cernan, which Slayton made back-up to the new Apollo 2, and as back up for the new Apollo 3, he selected Charles Conrad, Richard Gordon and Clifton Williams. We now had three crews in place plus their back-ups:

Apollo 1: Gus Grissom, Ed White and Roger Chaffee
Apollo 1 back-ups: Walter Schirra, Donn Eisele and Walter Cunningham.
Apollo 2: James McDivitt, David Scott and Rusty Schweickart
Apollo 2 back-ups: Thomas Stafford, John Young and Eugene Cernan
Apollo 3: Frank Borman, Michael Collins and William Anders
Apollo 3 back-ups: Charles Conrad, Richard Gordon and Clifton Williams

As the new-year dawned the Apollo 1 crew continued their preparations for launch. The scheduled lift-off date was 21 February 1967 when on 27 January 1967 they were conducting a simulation of the launch at the Cape Canaveral Air Force Station, Florida, on the actual launch stack that had already been assembled on Pad 34. There had been all sorts of problems with the Apollo spacecraft and to put it bluntly, it was not ready for spaceflight. But, what could possibly go wrong on the ground? NASA found out that day. Fire and death!

The Apollo 1 astronauts were conducting what was known as a 'plugs-out' test where the spacecraft relied on its own internal power as it would when the umbilical lines were disconnected prior to launch. The cabin's atmosphere was pressurized with pure oxygen to roughly 13% above normal sea-level atmospheric pressure making the environment highly flammable. The simulation was more than six hours old when a short circuit led to a fire. The large amount of flammable material in the oxygen rich cabin allowed the fire to start and spread rapidly. The fire quickly used up the oxygen resulting in a toxic atmosphere. The astronauts died as a result of cardiac arrest caused by oxygen starvation.

Up to this point NASA management had agreed with Deke Slayton that a Mercury 7 astronaut should, if possible, be the first man to walk on the Moon. Gus Grissom was, in a way, the last man standing of that group. Deke and Alan Shepard were both grounded and unavailable. Although they both hoped to regain active status neither had the experience necessary to jump straight into the command seat for the first Moon landing. John Glenn had retired from NASA, Scott Carpenter was medically disqualified and although Walter Schirra and Gordon Cooper had arguably the experience it was also clear that Schirra was not looking for a further assignment after his current one and Cooper was a hard sell to management for a perceived lack of focus. To all intent and purpose, the Apollo 1 fire ended any chance of a Mercury 7 astronaut becoming the first man to walk on the Moon.

There was no question of a manned launch until an exhaustive investigation was made of the Apollo 1 fire but that did not stop Deke Slayton assigning crews for when missions did start again. In early March 1967, he promoted Walter Schirra's crew to prime for the first manned Apollo mission and made Thomas Stafford's crew their back-ups. The James McDivitt and Frank Borman crews got the second and third missions respectively with Conrad's crew backing up the second flight and a new crew of Neil Armstrong, James Lovell and Buzz Aldrin backing up the third flight.

A decision was also subsequently made that unmanned launches would receive Apollo number designations and this led to the first manned mission eventually becoming Apollo 7. Each manned Apollo lunar focussed mission was sequentially numbered from then on and this is how I will show them in the rest of this article.

At this point it was hoped that the first lunar landing would be on the fifth or sixth manned Apollo flight. Deke Slayton had prime and back-up crews for the first three missions and if you follow Deke's normal rotation policy, we have the prime crews for the first six missions and therefore the first lunar landing crew.

Apollo 7: Walter Schirra, Donn Eisele and Walter Cunningham
Apollo 7 back-ups: Thomas Stafford, John Young and Eugene Cernan
Apollo 8: James McDivitt, David Scott and Rusty Schweickart
Apollo 8 back-ups: Charles Conrad, Richard Gordon and Clifton Williams
Apollo 9: Frank Borman, Michael Collins and William Anders
Apollo 9 back-ups: Neil Armstrong, James Lovell and Buzz Aldrin

By extrapolation of Deke Slayton's "miss two flights" rotation policy we then have:

Apollo 10: Thomas Stafford, John Young and Eugene Cernan
Apollo 11: Charles Conrad, Richard Gordon and Clifton Williams
Apollo 12: Neil Armstrong, James Lovell and Buzz Aldrin

So, in the spring/summer of 1967, it looked like one of the Conrad and Armstrong teams were most likely to be the first lunar landing crew. If the first lunar landing had been the fifth Apollo manned flight (as it turned out to be) then Charles Conrad, Richard Gordon and Clifton Williams would have been the first lunar crew with Conrad and Williams being the first men to walk on the Moon. But, that is not what happened in real time.

First up came another fatal aircraft accident leading to a change in crew. On 5 October 1967, Clifton Williams was killed whilst flying a T-38. He was the fourth astronaut to die in T-38 accidents. As well as Elliot See and Charles Bassett, NASA Group 3 astronaut Theodore Freeman had been killed in 1964 whilst flying a T-38. Williams, Bassett and Freeman were all part of the same 1963 NASA astronaut intake. Alan

Bean, who by coincidence was also a Group 3 astronaut and at that time was working on the Apollo Applications Programme (later known as Skylab), was brought into Charles Conrad's crew to replace Williams.

The next change came in early July 1968 as a result of a health problem for Michael Collins. He was going to need surgery on a bone spur. He was off the Apollo 9 crew and replaced by his back-up James Lovell. Buzz Aldrin was promoted to CMP on the Apollo 9 back-up crew because of Deke Slayton's rule that the CMP had to have spaceflight experience and rookie astronaut Fred Haise became the back-up LMP.

By now, the Lunar Module was facing delays and it became clear it was not going to be ready for its scheduled first Apollo test mission. Apollo 8 had meant to be an Earth orbit Lunar Module test flight to be followed by a high Earth orbit Lunar Module test with Apollo 9. By August 1968, NASA management were discussing making the Apollo 8 mission a lunar orbiting flight but without a Lunar Module.

Deke Slayton wanted to keep James McDivitt's crew with the Lunar Module, but there have been rumours that he gave McDivitt the option to go to the Moon on Apollo 8 and that McDivitt said no. McDivitt later said that he believed *"if I'd thrown myself on the floor and begged fly the* [Apollo 8] *mission, Deke would have let us have it. But it was never really offered."* Slayton did offer Apollo 8 to Frank Borman and he said yes. The back-up crews remained with the same prime crews so basically the Conrad and Armstrong back-up teams swapped.

Because of the swap of crews, the death of Clifton Williams and the health issue for Michael Collins we now have a new line-up:

Apollo 7: Walter Schirra, Donn Eisele and Walter Cunningham
Apollo 8: Frank Borman, James Lovell and William Anders
Apollo 9: James McDivitt, David Scott and Rusty Schweickart
Apollo 10: Thomas Stafford, John Young and Eugene Cernan
Apollo 11: Neil Armstrong, Buzz Aldrin and Fred Haise
Apollo 12: Charles Conrad, Richard Gordon and Alan Bean

Apollo 7 (flew 11-22 October 1968) made Apollo's debut as a manned spacecraft. The following month, Michael Collins was back-on flight status but he was not immediately reassigned. Apollo 8 (flew 21-27 December 1968) successfully completed its Moon orbiting mission. It now looked likely that Apollo 9 would be an Earth orbit Lunar Module test flight; Apollo 10 would be a Moon orbit Lunar Module test flight and Apollo 11 the first lunar landing. But there was still a change to come for the crews.

Deke Slayton had never intended Fred Haise to be in the running for the early Apollo flights and so he was stood down after serving as back-up for Apollo 8. The now fit again Michael Collins was assigned to Apollo 11 as CMP with Buzz Aldrin returning to the LMP position. However, Aldrin's place on the Apollo 11 crew was thanks to Neil Armstrong. Slayton, well aware that Aldrin was not everyone's 'cup of tea' offered Armstrong James Lovell as his LMP instead of Aldrin. Armstrong did not have a problem with Aldrin as his LMP so declined the offer. Armstrong also thought Lovell deserved his own command.

On 6 January 1969, Deke Slayton told Neil Armstrong, Michael Collins and Buzz Aldrin that they were officially the prime crew for Apollo 11. Finally we have the crew for the first Moon landing flight that we know from history, Armstrong, Collins and Aldrin. Even at this late stage it was not certain that they would perform the first landing mission. If something had gone wrong with Apollo 9 or Apollo 10 then Apollo 11 might have still been a precursor flight, but it was looking increasingly likely that they would be the first.

Apollo 9 (flew 3-13 March 1969) and Apollo 10 (flew 18-26 May 1969) went according to plan, which left Apollo 11 (flew 16-24 July 1969) to perform the historic first lunar landing mission. CDR Neil Armstrong was the first human to walk on the Moon followed by his LMP Buzz Aldrin. CMP Michael Collins orbited the Moon in the Apollo Command Module.

No one single event put Neil Armstrong, Michael Collins and Buzz Aldrin on the first lunar landing flight. You could argue that Alan Shepard's grounding was the first step.Then there was the death of Elliot See and Charles Bassett. We also have the loss of Gus Grissom which opened up the commander's slot to a number of candidates, and the swapsies of missions and crew members that all played a part in what crew flew Apollo 11. But in the final analysis, I proffer the opinion that it was just their turn to be assigned a flight and they fell, without doubt with some help from events described above, just right to be on the first lunar landing mission.

POSTSCRIPT

Deke Slayton in his autobiography maintains that following the death of Gus Grissom there was no *"cut and dried decision as to who should make the first steps on the Moon."* But what if Gus Grissom had not died? If Grissom (or indeed any Mercury 7 astronaut) was intended to take the first steps on the Moon then I am not sure how the other astronauts would feel about one of them being bumped just to shoehorn Grissom into the first landing flight and that is what must happen in this scenario because of the uncertainty of which mission would be the first. Can you imagine Deke Slayton going up to Neil Armstrong, Frank Borman, Charles Conrad, James McDivitt or Thomas Stafford and saying - sorry but I am kicking you off the crew for Gus - but that is perhaps a story better left unwritten.

Comments, acknowledgements and sources:

All dates for launch and landing (splashdown) are given in GMT unless otherwise stated.

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Small Steps and Giant Leaps:

Apollo Astronauts' First Words on the Surface of the Moon

By Ben Evans

At 10:56:15 p.m. Eastern Time on 20 July 1969, Neil Armstrong lifted his left boot over the rim of Lunar Module (LM) Eagle's bowl-shaped footpad and planted it firmly onto the Moon's surface. It was perhaps the most remarkable accomplishment in history and certainly the most spectacular triumph of the 20th century. In the seconds that followed that initial step, Armstrong followed up with words which have become ingrained—and sometimes parodied—into the human psyche. "That's one small step for man," he intoned, "one giant leap for mankind." This summer, as we celebrate 50 years since those first steps, it is interesting to consider where Armstrong's words came from. And, moreover, the stories behind the first words uttered by the other five Apollo crew commanders as they stepped onto the Moon are just as intriguing.

For Armstrong, notoriously quiet, shy and unassuming, it was difficult to ascertain where his words originated. Even his Apollo 11 crewmates Mike Collins and Buzz Aldrin, who asked him pointedly what he would say during the journey to the Moon, had no idea; Armstrong simply told them that he was still mulling it over. "My own view," he told biographer James Hansen in *First Man*, "was that it was a very simplistic statement: what *can* you say when you step off something? Well, something about a step. It just sort of evolved during the period that I was doing the procedures. I have never thought that I picked a particularly enlightening statement. It was a very simple statement."

Over the years, some have argued that the phrase was drawn from J.R.R. Tolkien's *The Hobbit*, in which Bilbo Baggins leaps over Gollum; indeed, Armstrong would later buy an Ohio farmstead which he named 'Rivendell'. But in truth, the astronaut did not even read Tolkien's famous work until long after the mission. In the sacks of mail that Armstrong received before launch, the ideas came aplenty, ranging from biblical passages to lines from Shakespeare. Some scholars also questioned whether he meant to say 'man' or 'a man' in those famous words. In his seminal book *A Man on the Moon*, Andrew Chaikin believed that the indefinite article 'a' was forgotten, rather than necessarily lost in the crackling Moon-to-Earth radio transmission. Indeed, Armstrong insisted later that the 'a' *should* be inserted in parentheses and journalist Peter Shann Ford noted that transmission technology in 1969 must shoulder some blame. Still others counter that the singular word 'man', although ordinarily referring to the entire species, can also refer to an individual, with or without the indefinite article.

For an engineer and test pilot like Armstrong, first words were probably not at the forefront of his mind. In much the same way, he always considered the actual landing on the Moon as far more important—and tricky—than his first steps on alien soil. But for successive Apollo crews, the awareness that they were among only a handful of humans ever to visit this desolate place allowed them to forge their own 'first words'. Some were rooted in humour, others in the yearning for science and exploration and still others were a reflection of their own personal journeys.

Take Apollo 12's Pete Conrad, for instance. He could certainly speak appropriate whenever protocol dictated, but also swore like a sailor, and was particularly irritated by people who convinced themselves that astronauts were *told* by NASA brass what to say. In the summer of 1969, Conrad and his wife Jane entertained the Italian journalist Oriana Fallaci, who was certain in her conviction that Armstrong had been instructed to say his famous words. There was no way, she reasoned, that he could possibly have dreamed up such poetic words on the spot. All of Conrad's attempts to persuade her otherwise were in vain.

"Okay," he said. "I'll make up *my* first words on the Moon, right here and now." Being one of the shortest astronauts, an idea popped into his head.

"Impossible," scoffed Fallaci. "They'll never let you get away with it!"

"They won't have anything to say about it," Conrad replied. "They won't know about it, until I'm on the Moon."

They shook on it and made a $500 bet. In November 1969, the short, wiry Conrad set foot on the lunar surface and spoke: "Whoopie! That may have been a small one for Neil, but it's a long one for me!"

Sadly for Conrad, Fallaci never paid up…

Fifteen months later, in February 1971, Apollo 14 commander Al Shepard made his first steps on the Moon, with some fitting words of his own. "It's been a long way," he breathed, gazing across the bleak lunar landscape, "but we're here." A figurative and literal comment, indeed, for the quarter-million-mile journey to get there had been far longer than Shepard's previous 15-minute suborbital 'hop' in May 1961, when he became America's first man in space. However, another reason may have laid behind these words. Following his first flight, Shepard had hoped to fly again and, but for a recurrent inner-ear disease, might have flown one of the Gemini missions. Instead, his ailment meant that he was grounded for most of the 1960s and could not even fly an aircraft alone. Eventually, he sought surgical intervention in 1968 and by the spring of 1969 was recovered and back on flight status. Twelve years after being chosen as one of America's first astronauts, and ten years since becoming his nation's first man in space, for Shepard it had been a long way, indeed.

With the completion of Apollo 14, only three more lunar landings remained and Apollos 15, 16 and 17 were designated "J-series"

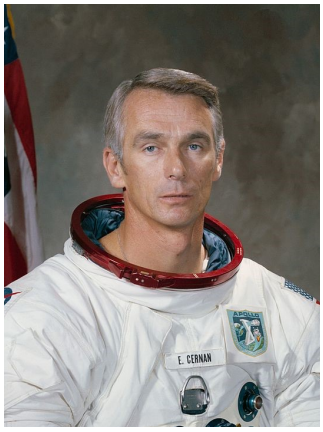
Neil Armstrong

Dave Scott

Charles Conrad

John Young

Alan Shepard



Gene Cernan

missions, with lunar rovers, longer stay-times of up to three days on the Moon, three Moonwalks and a larger haul of cargo. It is unsurprising, therefore, that Apollo 15's focus should have been upon science and exploration, particularly as it landed in the Hadley-Apennine mountainous region; arguably, one of the most spectacular landing sites. And when Apollo 15 commander Dave Scott set foot on the surface, discovery and science were clearly at the forefront of his mind. He had taken a great deal of active interest in lunar geology, which was quite unusual for a test pilot. "As I stand out here in the wonders of the unknown at Hadley," he said, "I sort of realise that there's a fundamental truth to our nature. Man *must* explore…and this is exploration at its greatest."

Eight months later, in April 1972 Apollo 16's John Young became the tenth man to walk on the Moon, setting foot on the terrain of the Descartes highlands. As another J-series commander about to embark on a mission of exploration, his words were equally fitting. "There you are, our mysterious and unknown Descartes highlands plains," he said. "Apollo 16 is gonna change your image!"

And for Apollo 17 in December 1972, the final roll of the dice occurred when the last footsteps on the Moon for the remainder of the 20th century took place. Commander Gene Cernan, therefore, had words not for himself or even for science and exploration, but rather for the hundreds of thousands of Americans who had enabled this remarkable feat of engineering. "As I step off at the surface at Taurus-Littrow," said Cernan, "we'd like to dedicate the first step of Apollo 17 to all those who made it possible."

Of course, the six Apollo commanders who brought their ships to a smooth landing on the Moon—Armstrong, Conrad, Shepard, Scott, Young and Cernan—were not the only ones to leave their bootprints in lunar dust. So too were the Lunar Module Pilots (LMPs), who added their own first words to a memorable mix. Apollo 11's Buzz Aldrin clambered down the ladder and described the scene at the Sea of Tranquillity as "magnificent desolation", whilst Apollo 15's Jim Irwin took a misstep on the ladder and only just caught himself from falling onto his backside on the Moon and Apollo 16's Charlie Duke simply exulted "Fan-*tas*-tic!" in his North Carolina drawl. And geologist Jack Schmitt, one of the most serious of them all, actually came out with a light-hearted quip. Preceded down the ladder by Cernan, he enquired in self-deprecating fashion: "Hey, who's been tracking-up my lunar surface?"

But there remains one Apollo commander who never got the opportunity to utter first words on the Moon. Jim Lovell, who led the 'successful failure' of Apollo 13 in April 1970, forever lost his chance to set foot on alien soil. His exact words—whether he ever planned them or not—can never be truly known. But with a mission emblem which bore the legend *Ex Luna, Scientia* ('From the Moon, Knowledge'), it can be inferred that Lovell's emphasis was upon exploration and discovery. And this may have formed the basis for his first words.

Fifty years after Apollo 11, all eyes are now intently set on who might be the next generation of human lunar explorers. Following President Donald Trump's much-publicised announcement of a return there by 2024—and his equally-much-publicised tweets in June 2019, which imply the *opposite*—it can be hoped that at least one of the Apollo Moonwalkers may still be alive when the next wave of explorers follows in their footsteps. NASA Administrator Jim Bridenstine has made frequent use of the soundbite "the first woman and the next man" when describing our return to our nearest celestial neighbour. But when the day of that long-awaited return comes, what might their 'first words' be?

Only time will tell.

APOLLO 11: A PERSONAL JOURNEY

By Rob Wood

It was the spring of 1969 and 'Moonslaught: Purnell History of the 20th Century Magazine Special' appeared at my local Newsagent, barely a 100 yard walk from where I lived. The cost was four shilling. It was all about the 'space race' and was, without doubt, the greatest thing since sliced bread especially to a starry eyed twelve year old who had recently become interested in real spaceflight. I was definitely hooked. I looked to the future with hope and expectation and dreams of not only watching humans walk on the Moon but also Mars and other bodies in our solar system.

The Moonslaught magazine was released as part of the build-up to the first Moon landing. It gave biographical details on what would be the Apollo 11 crew, provided background for the flight and detailed the history of the 'space race' through to the early part of 1969. It included information on the Soviet Space Programme as well as the United States. It was not a children's publication; it was for adults interested in the Moon landings but to a not quite teenager who was genuinely interested it also hit the spot. The magazine special was written by Reginald Turnill who was the BBC's Air and Defence Correspondent.

Sunday evening, 20 July 1969, I was sat in the living room at home with my parents and my Mom's parents. We were watching the Moon landing on the telly. Amazing stuff, I was bouncing, okay perhaps not bouncing, I was after all a fairly boring kid with my head always buried in some book or other. The Eagle has landed; Apollo 11 was on the Moon's surface. We were in British Summer Time so for us the landing came at seventeen minutes after nine in the evening (21:17 BST). At some point we became aware that the moonwalk (I knew that the correct term was EVA) was to start earlier than planned. Looking at the 'Lunar Surface Journal' on line tells us this decision was made a little after eleven that evening.

Three hours to go. That would make it a little after two in the morning. Forget bedtime! This was too important. My parents were less than convinced. To be fair my Dad probably needed to be up early for work but me, well the school summer holidays had just began. It was decision time? My parents were in agreement that the Moon landing was wonderful but they were not going to lose a night's sleep over it. But, but, they understood how interested I was in it and they were okay with me staying up. Yippee, *"Thanks Mom and Dad."* Mom, Dan, Nan and Granddad, one-by-one they all went off to bed.

I was on my own. I had never stayed up all night before. There were lots of firsts at this time – the first Moon landing; the first Moon EVA and the first time Rob was on an all-nighter. Time moved on as did the time for the start of the EVA. As the astronauts struggled to get ready I struggled to stay awake. I grabbed a flannel and dampened it with cold water and rubbed my face. That should wake me up. Neil Armstrong was on the ladder and reached the footpad of the Lunar Module.

What, what, what happened there. There was Armstrong. He was on the lunar surface. Oh no, I could not believe it, I had missed that small step for man. I had nodded off. I don't remember being overly disappointed because I had the majority of the EVA to watch and was too enthralled to feel disappointment. At least that little power nap had done the trick. I was wide awake for the rest of the EVA.

That first step had taken place at four minutes to four on Monday morning (03:56 BST). By the time the EVA ended it was a little after six in the morning (06:11 BST) and daylight was shining through the window. The astronauts would be heading for a rest period soon. I decided to head for bed to grab my own rest period and leave the coast clear for my Mom and Dad who would be up shortly.

I don't remember how long I slept and I don't have strong memories of the rest of the mission although I know I watched the events unfold on television. As I look back, I have a little low level annoyance at myself for not being able to stay awake but c'est la vie.

National Concert Hall Dublin

Fast forward 34 years or so and it is 17 November 2003, I am in the National Concert Hall in Dublin and am about to pull another all-nighter. I am in a shirt, tie and suit, sat in an audience of at least 800 people. We are about to hear Neil Armstrong live on stage. Later that evening I will actually get the chance to meet and speak to him in person.

The news of the event had broken a few months previously and I found out when details were posted on the Collect Space website. There was a VIP package including pre-speech drinks and a post-speech dinner. Armstrong would be at the dinner and there would be an official photograph with the man himself. Via the Collect Space message board and private emails between the Collect Space fraternity a number of us booked for the event. Through contact with the organisers we managed to arrange for all of us to sit on one table.

There was about ten of us Collect Spacers who had booked the VIP package plus a few that had ordinary tickets. Some of us planned to meet up in a bar of a hotel near the venue. Andrew, Dave, Derek, Eamonn, Geoffrey, Matt, Paul (plus Mrs Paul), Rob and Steve (apologies to those I have missed out) spent a little time talking about spaceflight. Matt had brought various bits of spacesuits including Schmitt's back-up lunar EVA glove.

At about 7pm the VIP guests arrived at the National Concert Hall for the drinks reception before heading up to our reserved seats in the balcony for the 8pm start of the 'Face to Face interview. Gay Byrne, an Irish presenter and host of

radio and television, was our Michael Parkinson for the evening. Gay did a wonderful job with his soft control of the interview. Gay's intelligent questioning and prompts brought out the best in Armstrong. Forget all you have heard about Armstrong not being a good speaker. Despite a little nervousness at the beginning, perhaps brought on by the wonderful and long standing ovation he got when he first came on stage, he was articulate, enthralling and humorous. He talked about his life, his flying career and his spaceflights. There was then a Q&A period. Nobody cared we were overrunning. I got the feeling even Armstrong was enjoying himself. I think this part of the evening was scheduled to last about 90 minutes but it was close to nearly double that.

The dinner was due to start at 10pm but we were well behind schedule. The evening was due to end at about midnight but my memory recalls that we had not even started eating by that time. There had been a lot of discussion amongst the Collect Space crowd about what we would say to Armstrong when we met him. After we had all got home a lot of us told stories on the Collect Space message board and I was no different.

"Those who have already posted have told you about the wonderful evening we had. I do not think there was much else we could have asked for apart from more time with the man himself. I think for my bit on the night I will tell you a little story.

For the last few weeks I have been building up to my meeting with Neil Armstrong. Reading 'Carrying the Fire' and some of 'First on the Moon', 'Gemini' etc. I wanted to find the perfect question; something profound. I did not want to ask the usual "what was it like to..." type of question. I decided Gemini 8 was a promising area to study.

Despite all this enjoyable research I had not found the question required. On the Saturday before 'Face to Face' I was at a space conference in Birmingham, England. The one with the no show from Polyakov because of illness. I was chatting to a friend and I told him of my dilemma. He suggested questioning him on his pilot skills. Great idea, thanks Dave if you are reading. On my way to Ireland I worked the question in my head. This continued right up to the start of the event.

The problem was, could I pluck up enough courage to ask the question during the Q & A session. Perhaps my question was too long? I thought of quicker Gemini and Apollo questions as back-ups. The problem with the quicker questions was that Gay Byrne had done his homework and they came up during his questions. In the Q & A session the 'chickens clucked loudly' (for those of you across the 'pond' a British way of saying I was too scared to speak in front of such a large audience). Still, there was always at the supper.

To return to the start of Gay Byrne's interview, he had asked Neil Armstrong about his family links to Ireland and he explained that his family had originated from Scotland but had to leave because they kept 'borrowing the English cattle'. Some came to Ireland although he was not sure if he was linked to this part of the family.

You are probably thinking why has Rob gone off subject? I have not and all will be revealed in a moment. The second course was arriving in the supper room at about the same time as Neil Armstrong. Sod the food, this is the main event. However, they are doing the tables in order and we have number 17 so a little time will elapse before it is our turn. I eat the food but keep making quick glances in his direction.

It is now our table's turn. A quick slug of wine, make sure my tie is straight, my eyebrows are under control and we have lift -off. I think, I don't have time for my profound question. So what do I say to him? You remember that bit about the cattle. I told him I was English but that he should not worry and I would not ask him for our cattle back. He laughed. The photograph was taken and I have a great memory. Maybe next time I will ask him that question.

What a fabulous evening great company, great conversation and only one hour sleep but that is another story..."

After I had posted that another of the attendees from the evening, a previously mentioned Geoffrey, posted, *"Thanks for that! I've heard it before because I was sitting beside you, but it was still good to hear it again!"*

I am not sure what time we left the venue but some of us decanted to a still open hotel bar. At some point I managed about an hour's sleep before it was time to make tracks for home.

Acknowledgements and sources:

Collect Space; 40 Orbits of the Sun ©1999 by Rob Wood; Moonslaught: Purnell History of the 20th Century Magazine Special ©1969 by Reginald Turnill; Timeanddate.com

Consistent Advocate for Safety:

A Chat With Shuttle Commander Sid Gutierrez

By Ben Evans

Almost a decade has now passed since the end of the Space Shuttle era and the names of most of the hundreds of men and women from a dozen sovereign nations who flew Columbia, Challenger, Discovery, Atlantis and Endeavour between April 1981 and July 2011 are virtually unknown to all but the diehard space enthusiast. Yet one astronaut among their ranks went on to become the first—and only—person of Hispanic ancestry to serve as both a shuttle pilot and commander. He flew two highly successful science missions, racked up almost three weeks in space and ultimately departed the astronaut profession because of his concerns about the inherent safety of the shuttle and NASA's unwillingness to address them. In a recent interview, Sid Gutierrez described both the Challenger and Columbia accidents as "not surprises". And flight safety followed Gutierrez around for his entire astronaut career. Even his first mission assignment came on the back of an appalling tragedy.

Born in Albuquerque, New Mexico, on 27 June 1951, Gutierrez completed high school in his home town and entered the Air Force Academy to study aeronautical engineering. Whilst there, he was a member of the National Collegiate Championship Parachute Team, accomplishing over 550 jumps and attaining the rank of Master Parachutist. After graduation in 1973, Gutierrez commenced pilot training at Laughlin Air Force Base in Texas, and remained there for several years as an instructor on the T-38 Talon jet aircraft. In 1977, he finished a master's degree in management from Webster University and continued his Air Force career, flying the F-15 Eagle out of Holloman Air Force Base in New Mexico. He graduated as a test pilot in 1981 and worked on the F-16 Falcon Combined Test Force, with specific emphasis on the new fighter jet's airframe and propulsion system. Gutierrez was at Edwards Air Force Base in California in May 1984 when he learned of his selection by NASA as one of seven new shuttle pilots.

NASA portrait photo of Sid Gutierrez.

Autographed copy curtesy Ben Evans

"Of course, there were a number of other test pilots who had applied," Gutierrez explained. "The announcement of the selection was delayed for more than a month, so everyone was on edge, waiting for a call. The rumour was that if you got a call from John Young—the chief of the astronaut office—or George Abbey, head of flight crew operations, you had been selected. If the call was from Duane Ross, the individual managing the selection process, you had not been selected.

"I was returning from lunch and a good friend of mine told me they were finally calling folks," continued Gutierrez. "I walked into my office knowing my long-awaited answer depended on who called me. My assistant was excited. She told me I had just received a call from Duane Ross at NASA. My stomach sank. Of course, she did not know about the rumour, so she was excited for me, thinking I was getting good news. I tried as best I could to contain my disappointment and act excited.

"I was scheduled for a fun mission in the F-16 that afternoon and decided to go fly the flight, rather than ruining it with the official bad news. I had actually picked up my helmet and harness and was headed out to fly, when I had second thoughts about Duane Ross. I thought: 'Poor guy. No-one wants to hear from him. His job is to spend his day disappointing people. And now he's going to spend a couple of hours waiting for me to call him back.' As a courtesy to Duane, I went back in and returned his call immediately. When he answered, he started talking about everything *but* the selection process. I was thinking 'Just get it over, Duane. We both know what you are going to say. I'm a big boy. I can take it.'"

Then Ross went quiet. "I bet you're wondering why I'm beating around the bush?"

"Actually, I am," replied Gutierrez.

"Well, I'm trying to keep you on the phone until George Abbey is available to talk to you," Ross said. "Will you be around for George to call you back?"

"Absolutely," retorted Gutierrez. Shortly thereafter, Abbey came on the line and formally asked him to join NASA's astronaut office.

Graduating from Astronaut Candidate (ASCAN) training in June 1985, Gutierrez was assigned to the Shuttle Avionics Integration Laboratory (SAIL), where he "flew" simulated shuttle missions to evaluate and verify flight software loads. When Challenger was lost in January 1986, he went to NASA Headquarters in Washington, D.C., as an action officer for the agency's associate administrator for spaceflight, helping to co-ordinate requests during the Rogers Commission hearings and aftermath. The head of the action office at the time was a veteran astronaut named Bryan O'Connor. Little could Gutierrez have known when he worked under O'Connor for those few dark months in 1986, but the two of them would end up flying into space together a few years later.

As NASA rose from its knees and prepared to fly again, Gutierrez worked throughout 1986 and 1987 to recertify the orbiter's main engines, propulsion system and external tank, before heading up the development, verification and future requirements definition of the shuttle's flight software. In June 1989, he took his wife and children on vacation to the East Coast of the United States, visiting relatives in Ocean City and touring historic sites around Washington, D.C., before staying at a friend's cabin in West Virginia.

"We were not expecting any new assignments to be announced for another month or so," Gutierrez recalled. Then, on the morning of 17 June, veteran astronaut Dave Griggs—who was training as pilot of STS-33, scheduled for launch later that year—died suddenly and shockingly in the crash of a vintage aircraft. Due to the short period of time available before STS-33, his place was taken by veteran shuttle pilot John Blaha, who had flown only a few months previously. But Blaha had himself recently been assigned to another mission, STS-40, a Spacelab life sciences mission planned for June 1990. Suddenly and unexpectedly, STS-40 needed a new pilot.

The launch was far enough into the future for a "rookie" astronaut to fit the bill and on 29 June Gutierrez was assigned to STS-40. However, he had no idea about it. "It was the days before cell phones or even personal pagers, so I left my assistant with good phone numbers to reach me up until leaving the cabin in West Virginia," Gutierrez told me. "From there on, back to Houston, I told her we would just drive along and stop when and where we felt like it, so there were a few days when she could not reach me." One morning, he read a newspaper story about Griggs' untimely death. "I thought briefly about the possibility of a funeral at Arlington [National Cemetery], but heard nothing. It did not cross my mind that his death would have an impact on my flight assignment.

That weekend, the family got home to Houston and slept in. Late in the morning, Gutierrez went out to pick up a newspaper and his neighbour congratulated him. "I thought he was being sarcastic and making a joke about making it through an extended family vacation driving across the country," he remembered. "He realized I had missed the point" and told Gutierrez about the flight assignment, which had occurred days earlier. "He gave me some idea of what day it had occurred and I went back in, rummaged through the pile of old papers and found the article where NASA announced my assignment."

For their part, NASA had tried to contact Gutierrez in vain. Later that day, he bumped into acting chief astronaut Mike Coats in the grocery store, who congratulated him, but quickly realized he had not yet been informed. Shortly thereafter, STS-40 Commander Bryan O'Connor—Gutierrez's former boss at the Challenger NASA action centre—phoned to congratulate him. "They planned to notify all the crew members before the official announcement," Gutierrez said, "but they tried to reach me about half an hour after we had left the cabin. After being advised by my assistant that we were out of contact somewhere along the Skyline Drive, they went ahead with the official announcement."

Gutierrez and his crew trained for two years. Shuttle delays through the summer of 1990 meant that STS-40 did not fly until June 1991. The nine-day mission carried the first dedicated Spacelab life sciences payload, with three physicians and a biochemist among the crew. Remembering the experience, Gutierrez's thoughts were instantly drawn to spicy taco sauce. "Astronauts figured out from experience that your taste buds become less sensitive in space," he said. "It may not actually be your taste buds themselves, but the result is that things that are tasty on Earth are bland on-orbit. Experienced astronauts know to include a number of spicy items in their menu to make eating more appetizing." As such, even items like dehydrated shrimp cocktail and even Rice Krispies, were horrendously combined with taco sauce to "improve" the taste.

"We had a full assortment of condiments in small plastic packets including mustard, ketchup, mayonnaise and hot sauce," Gutierrez said. "It soon became apparent that the hot sauce was going quickly and we would run out before the end of the mission. Being a Marine and wanting to maintain good crew morale, Bryan stepped in, commandeered all the remaining hot sauce and then distributed it evenly among the crew members. Everyone got an equal number of packets to use as they saw fit. I seem to recall getting seven packets. This became the medium of exchange. We left our wallets with any cash at the Cape and money is of no value on orbit. But hot sauce, that was worth something. Suppose it was your turn to clean the toilet. Two packets of hot sauce might be enough to entice a fellow crew member into taking on that task."

Following STS-40, Gutierrez became eligible to command his second flight. "Flight assignments leading up to my selection as a commander were being impacted by a mission that included the first Soviet cosmonaut to fly on the shuttle," he explained. "I knew I would be assigned soon, so I reviewed the upcoming flights. The one that caught my interest was STS-59." Gutierrez was great friends with the two science crew members—Linda Godwin and Tom Jones—for this dedicated mission to image the Earth's surface with powerful radar. He knew that STS-59 was an important flight for science and technology; so important, in fact, that the radar went on to fly three times between 1994 and 2000. "The data gathered by those three missions has had an impact on many aspects of Earth science, as well as navigation and aviation," said Gutierrez. "I knew it would it would be an important thing to be part of." Finally, he wanted a high-inclination flight and STS-59's 59-degree orbit would carry the shuttle over most of Earth's landmass. That and the international participation in the flight made it, in Gutierrez's words, "hard to beat".

"I understood all this the day I went in to talk with the chief of the astronaut office about upcoming assignments," he said. "In a very unusual move, he pointed to a board listing the three missions scheduled to be flown in the late winter and spring of '94. He said you can fly any one of those missions. In a heartbeat, I said I would like to fly STS-59. He immediately pointed out that it was not the next mission scheduled to fly and that I would be dropping back a slot or two in the rotation sequence. I smiled and said 'You said I could pick any of the three missions and I pick STS-59'. He smiled and said: 'Then, we will assign you to STS-59'." The assignment was formally announced by NASA in March 1993.

One of the tasks of a shuttle commander, in Gutierrez's words, was "to set the tone and create the culture for the entire mission", not only with the crew, but also with the training and payloads teams. "It is a lot of responsibility," he said. "The pilot shares some of that responsibility, because he or she must be prepared to take over any time the commander is incapacitated. Both must know the vehicle and the flight profiles, including all possible aborts, completely. But the commander concentrates on flying, the computer system and the environmental control system. The pilot is watching the main engines, the Reaction Control System, the hydraulics and the electrical system. They are both prepared to fly and land the vehicle, but the commander is the final decision-maker and he or she is ultimately responsible for pulling it all together."

Gutierrez's approach was to talk to other former shuttle pilots and commanders and gain their insights. "Bryan O'Connor involved me in many of these issues, which helped me prepare to be a commander myself," he explained. "There is a formal programme to train the commander in the technical aspects of the position, but those are minor compared with the rest of the responsibility. Before I flew as a pilot, I conducted my own training by going around and interviewing pilots who had already flown. I asked them what surprised them? What they wish they had spent more time working on? What they would do different? I did the same thing when I became a commander."

One seasoned veteran was Karol "Bo" Bobko, who flew once as a pilot and twice as a commander in the 1980s. "He told me that if he had to do it again, he would take his crew camping," Gutierrez said. "He said that working together in space is very much like camping. There is no-one to pick up after you; no janitors or cooks or assistants. Folks have to do those things for themselves. If someone is not pulling their weight in that regard, sorting it out in space when everyone is already stressed out is a bit late." Gutierrez took Bobko's advice and took the STS-59 crew on a two-day camping trip, followed by a meet-up with their families and children. "It was a great bonding exercise," he remembered. "The kids in particular became great friends, even though they varied extensively in age. When the stress of the actual flight arrived, they had other kids they knew they could relate to." Gutierrez and his wife, Marianne, also took the other couples on STS-59 out to dinner individually. "Of course, NASA didn't fund any of this 'extra' training," he said, "but I would do it all again."

STS-59 flew in April 1994 and ran for 11 highly successful days. During the flight, Gutierrez spotted the opportunity to prank. "I hate snakes," he admitted, "but while training before the flight, we discovered that pilot Kevin Chilton hates snakes even more than me." As far as Gutierrez was concerned, it was dog-dare that he intended to take up. Tom Jones purchased a realistic rubber snake from the Houston Zoo and the astronauts managed to get it aboard the shuttle by explaining that it was "a Herpetilian model" for an educational activity. "We reasoned that no-one would know what a Herpetilian model was, and they would be too embarrassed to ask," said Gutierrez. "The crew families usually put surprises in the same drawer for the crew to find when they get on-orbit, so we had to make sure we moved [the snake] before Kevin looked in that drawer and found it."

They put it in the drawer with Gutierrez's clothing, near Equipment Bay 5 on the shuttle's middeck, hoping that Chilton would stumble upon it later in the mission. "The first night on-orbit, we were all eating dinner together," Gutierrez recalled. "Kevin floated over to get something out of his clothing drawer near Equipment Bay 5 and suddenly pushed back and let out a yell. Equipment Bay 5 has the high-voltage stuff, so my first reaction based on the sound of his voice was that we had an electrical fire. Then we saw the snake. He had inadvertently opened *my* drawer, rather than *his*."

Four months after STS-59, in August 1994, Gutierrez announced his retirement from NASA. There were two principal reasons for his decision. Firstly, he wanted to give his family the chance to settle down in one place before his children entered high school. Secondly, he was concerned by NASA's unwillingness to address the underlying safety issues that plagued the shuttle fleet.

"The final Space Shuttle design was a compromise, driven by budget realities," he said. "The loss of the Challenger and later the Columbia were not surprises. Independent probability calculations completed before both accidents predicted the events very accurately. Given the inherent limitations in the basic design, NASA's planned incremental improvements in safety after both accidents changed the overall risk very little. The only way to improve the safety to the levels enjoyed by other manned NASA vehicles or even the Russian systems would have been to add a full-envelope escape system."

Such a system would have enabled crew survivability at any point during ascent—as Russia's Soyuz amply demonstrated in October 2018—and might have eliminated the 'black zone' during the Solid Rocket Booster (SRB) stage of flight, when no escape was possible. "I was a consistent advocate of this as an astronaut," said Gutierrez. "There was an opportunity following the first accident. The crew escape system that was installed was actually called the Phase I System. It was supposed to be followed by the Phase II system, but NASA cancelled that when public and political pressure eased after the return to flight. I attempted to raise the issue within NASA, but to no avail."

It brought to Gutierrez's mind the immense responsibility of the commander to ensure the safe flight and return of his crew. "In my mind, the weight of that responsibility came primarily from the loved ones that would be left without a spouse or without a Mother or Father if we didn't return safely," he explained. "By the time I flew as a commander, it was obvious to me that NASA did not intend to do anything significant to lower the risk. As a Commander I felt I had a pact with NASA to get that risk down and I felt that NASA reneged on that pact. I may have felt I could be a more effective agent of change outside of NASA, but I really can't say that was a major consideration when I left.

NASA official crew portrait for STS-40. Gutierrez is standing up on the right.

An autographed picture courtesy of Ben Evans.

"Nevertheless, that is what happened. A few years after leaving NASA I was appointed to the NASA Aerospace Safety Advisory Panel (ASAP). This gave me a great platform to advocate for an effective crew escape system. I served on the ASAP for three years and each year I was on the Panel we recommended that NASA investigate/pursue an effective crew escape system. The year before the Columbia accident, we advised NASA and both houses of Congress that unless things changed there would be a second accident. Our next report recommended a full-envelope crew escape system and changes in the way the safety program reported within the NASA structure."

The report arrived on NASA Administrator Sean O'Keefe's desk in March 2003, five weeks after the loss of Columbia and her STS-107 crew…

Ben Evans

ODD AND SOME LESS ODD FACTS ABOUT APOLLO 11

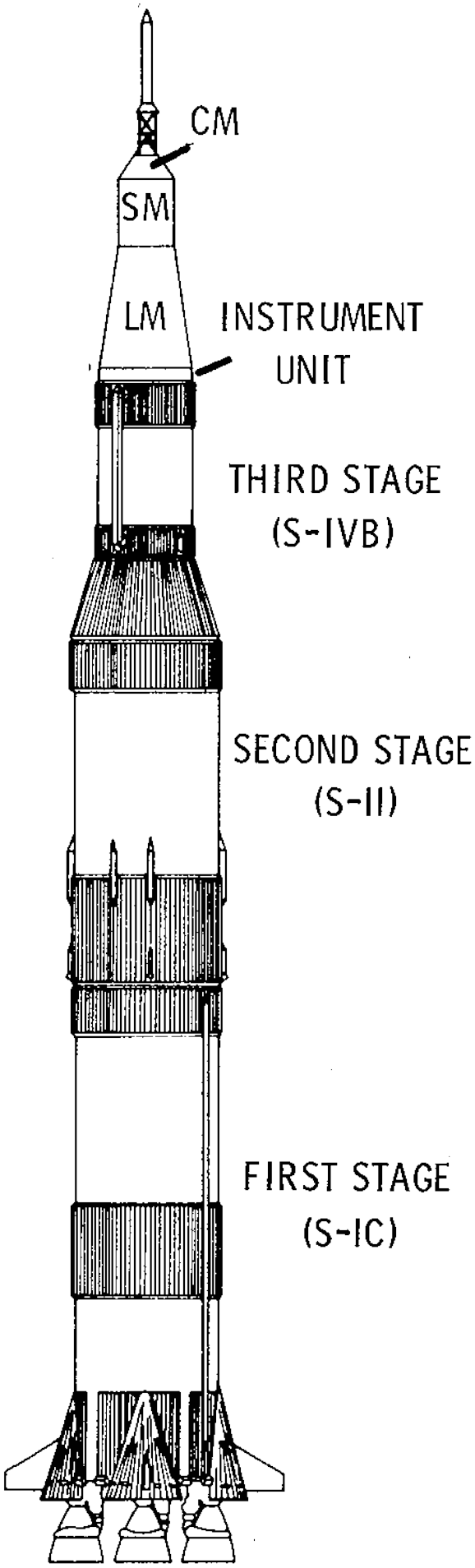
By Rob Wood

- Neil Armstrong is the only member of the Apollo 11 crew not to have written an autobiography. There is an authorised biography, First Man ©2005 by James R Hanson. Michael Collins wrote Carrying the Fire ©1974 and Buzz Aldrin has written numerous books including several that can be described as autobiographical works, including Return to Earth ©1973, Men From Earth ©1989 and Magnificent Desolation ©2009.
- All three Apollo 11 astronauts were born in 1930.
- Each member of the Apollo 11 crew had made one previous spaceflight. All were during the Gemini Programme.
- Both commanders of the prime and back-up crews, Neil Armstrong and James Lovell, were born in the same US State – Ohio.
- Very few US astronauts have been born outside of the USA but coincidently both the Command Module Pilots on the prime and back-up crews were. Michael Collins was born in Italy and William Anders was born in Hong Kong. They were the only astronauts selected in the first three NASA groups to have been born outside the United States.
- Michael Collins is the only member of the Apollo 11 crew to have only two names. It certainly saves time when filling in forms.
- Buzz Aldrin's mother's maiden name was Moon.
- No one on the Apollo 11 crew flew in space again.
- Neil Armstrong had less than 11 hours of spaceflight time prior to Apollo 11 but was not the most inexperienced commander of an Apollo Moon landing flight. Alan Shepard who commanded Apollo 14 had only flown a Mercury sub-orbital mission lasting only 15 minutes prior to his Moon mission.
- Armstrong was selected as an astronaut in 1962 (NASA Group 2). However, it could reasonably be suggested that this was the fourth time he had been selected as an astronaut. He had been nominated for the USAF 'Man in Space Soonest' project (1958); picked for the USAF Boeing X-20 Dyna-Soar spaceplane project (1960) and flew the North American X-15 hypersonic research aircraft (1960 to 1962), which could be described as the first spaceplane. It flew to the edge of space and in 1963 twice crossed it [100km height] but that was after Armstrong had joined NASA's astronaut corps.
- And almost finally, NASA officially announced the Apollo 11 crew to the public on 9 January 1969. At least that is what a lot of sources say including NASA retrospectives on the mission. However, I cannot find the actual release in NASA's archives so I cannot confirm that this date is accurate. I am sure someone out there has the proof.

I end with a question. What does a dead trout and a Chinese rabbit have to do with Apollo 11? Here is a clue – read Mike's autobiography Carrying the Fire. Answers in the next issue of CapCom.

Before I sign off I would just like to recommend Mike Collins book 'Carrying the Fire'. It is sometimes irreverent and requires a parental guidance warning but you will not find many better books on spaceflight. In fact you might not find ANY better books on spaceflight.

The odd facts have been compiled from various sources and unless otherwise stated are: Collect Space; Findmypast.co.uk; First Man ©2005 by James R Hanson; NASA; *Spacefacts;* Who's Who in Space ©1999 by Michael Cassutt; Wikipedia.

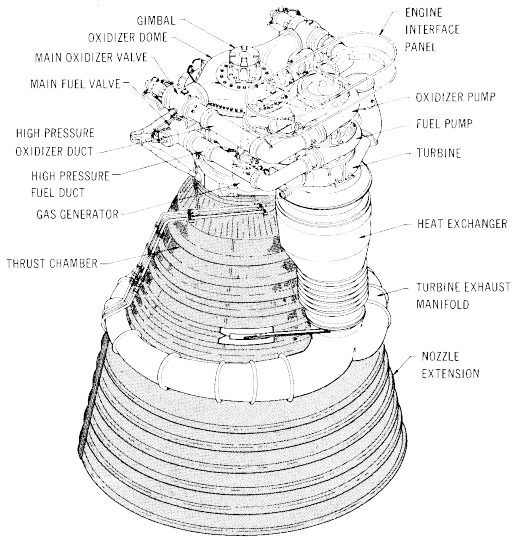


The Rocket Power of Apollo

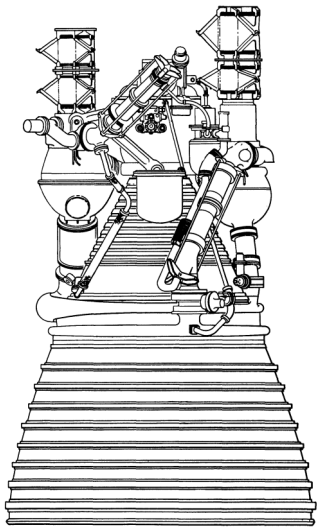
By Dave Evetts

There's a little bit more to launching a rocket into space than putting a match to the blue touch paper, but rocket engines work on a simple principle. Mix fuel with oxygen, ignite, and you're off.

Apollo flew to the Moon on the Saturn V rocket. Five huge rocket nozzles are visible at the base of the first stage. These nozzles are the external parts of the F-1 engine with the combustion chamber and turbopumps inside. The turbopumps feed fuel and oxygen into the chamber where they are mixed and ignited with the expanding gases providing thrust as they exhaust through the nozzles. Both fuel and oxygen are stored in a liquid form and they are surprisingly ordinary materials. The fuel is kerosene, similar to jet



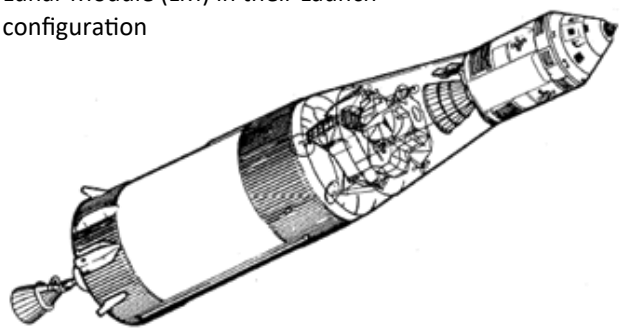
fuel and related to the paraffin used in greenhouse heaters. The oxygen is a gas in the air we breathe but chilled so that it condenses into a liquid.

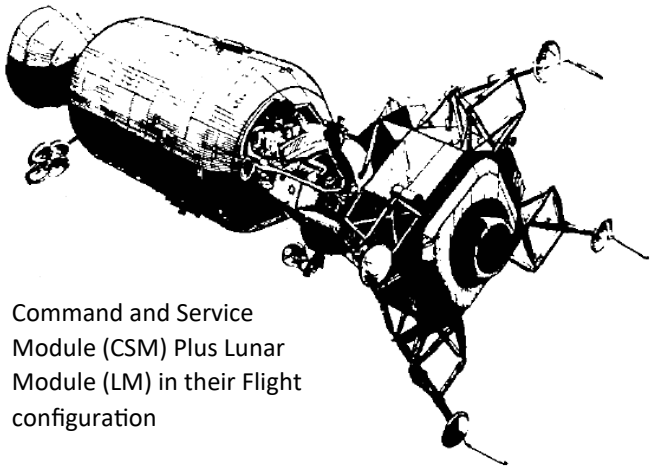


Above: F-1 engine, 1,522,000 lbs thrust

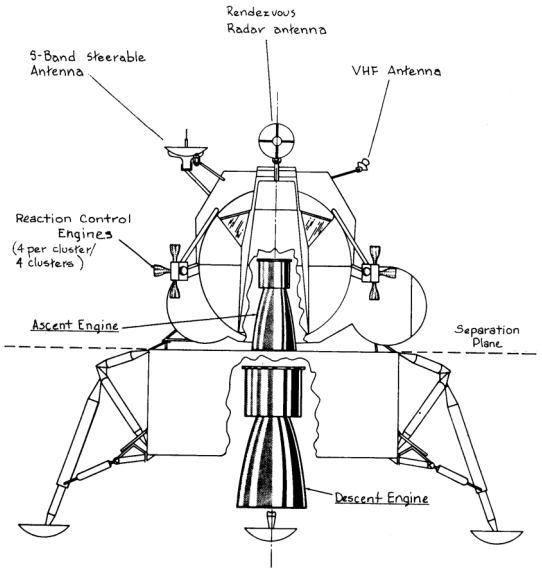
Right: J-2 engine, 109,000 lbs thrust at sea level; 232,000 lbs thrust in vacuum.

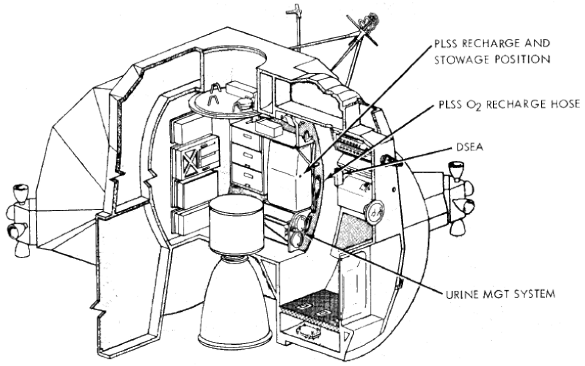
Command and Service Module (CSM) Plus Lunar Module (LM) in their Launch configuration





Command and Service Module (CSM) Plus Lunar Module (LM) in their Flight configuration





LM CABIN INTERIOR, RIGHT HALF

The same liquid oxygen, known as LOX, and kerosene fuel, called RP-1, is used in the J-2 engines of the 2nd and 3rd stages of the Saturn V. Super-cold or cryogenic LOX/RP-1 tanks cause the atmosphere to freeze into a layer of ice on the rocket. That's what you see falling away in close-up film of a Saturn V launch.

Riding on top of the rocket sit the Command and Service Module (CSM), and Lunar Module (LM). A single engine on the CSM is used for two critical moments; slowing down to enter lunar orbit and accelerating to leave the Moon again for return to Earth. A failure of the engine at either point would be disastrous. A different combination of liquid fuel and oxygen is used to increase its reliability. Oxygen is supplied to the reaction in the form of nitrogen tetroxide which spontaneously reacts with the Aerozine 50 fuel. The latter is a mix of highly toxic and unstable hydrazine and stable UDMH. No ignition system is needed; these materials burn as soon as they mix in a hypergolic reaction.

CSM Space Propulsion System engine, 20,500 lbs thrust.

The Aerozine 50 and nitrogen tetroxide are also used in the Lunar Module for the Descent Engine that takes it from lunar orbit to the surface and the Ascent Engine that returns the moonwalkers to the CSM. The Descent Engine can be throttled up and down by the crew to adjust their rate of fall.

LM Descent Engine, 10,000 lbs thrust.

LM Ascent Engine, 3,500 lbs thrust.

Comparisons

The Space Shuttle used 3x RS-25 SSME (Space Shuttle Main Engine) each of about 500,000 lbs thrust using cryogenic LOX and liquid hydrogen combined with two boosters of 3,300,000 lbs thrust each. The boosters were made of 4 tubular segments stacked on top of each other. Inside was a hard, rubbery material made of the propellant mixed with a binding agent. The propellant combined the fuel (powdered aluminium) with its oxygen source (ammonium perchlorate), ready to burn together when ignited.

NASA's new Space Transportation System (STS) will use similar solid rocket boosters but with 5 rather than 4 segments to give 3,600,000 lbs thrust each. The boosters will be attached to a central core using four modified RS-25 SSME's.

Solid fuel rockets are much simpler than liquid-fuel engines. A significant disadvantage of solid fuel is that once ignited, it cannot be turned off.

SpaceX's Falcon Heavy uses LOX and RP-1 in its Merlin engine. The 27 engines in its first stage give a total of 5,130,000 lbs of thrust at sea level.

Russia's Proton uses six engines in its first stage, each producing about 330,000 lbs thrust at sea level. These engines use the easy-to-store but highly toxic UDMH fuel and nitrogen tetroxide oxidiser.

Sources:

NASA press kits, www.astronautix.com

THE EAGLE HAS LANDED

By Rob Wood

Neil Alden Armstrong, Michael Collins and Edwin Eugene 'Buzz' Aldrin were sat in their Command and Service Module (CSM) on top of a three-stage Saturn V rocket. This 363 foot tall monster of a rocket was developed to take US astronauts to the Moon. At nine seconds before lift-off, the five huge first-stage engines are commanded to ignite. The thrust level grows and the hold-down clamps are released as the countdown clock reaches zero. Five and a half hours earlier the astronauts were waking up.

Deke Slayton was a Mercury 7 astronaut who was grounded because of health issues and put in charge of astronaut selection and astronaut flight assignments. He had put together the Apollo 11 crew and it was his job to wake them up. It was a little after 04:00hrs local time (Eastern Daylight Time or EDT) on 16 July 1969. Armstrong, Collins and Aldrin showered, dressed and then underwent pre-flight medical checks. Breakfast was at 05:00 EDT: steak, eggs, toast, juice and coffee. Then it was time to suit up. Shortly after 06:00 EDT they were in their pressurized spacesuits and by 06:30 EDT they were in the transfer van heading towards Launch Pad 39A where their spacecraft and launch vehicle awaited. Armstrong got into the Apollo Command Module first followed by Collins and Aldrin. The hatch was closed by 07:52 EDT. It was now 100 minutes to the planned lift-off time.

The launch site, situated on the East Coast of the United States in the State of Florida, is historically known as Cape Canaveral, but from 1963 to 1973 it was called Cape Kennedy after US President John F Kennedy. Launch Pad 39A is part of Launch Complex 39. At the time of Apollo 11, Launch Complex 39 had a second pad, 39B, which was also used during the Apollo Programme. A third pad, 39C, was built in 2015 for small-lift launch vehicles.

For the launch of Apollo 11 NASA had invited more than 20,000 VIP's. On the night of 15 July 1969 every room within 100 miles of the Cape Kennedy launch site that could be rented was rented. By the morning an estimated one million spectators were watching from the highways and beaches in the vicinity of the launch site. NASA had issued 3,500 press accreditation badges including some to Russian journalists. The Apollo 11 press kit, which was released more than a week earlier, showed a scheduled launch time of exactly the time it happened. The official countdown had started five days before launch and was accomplished with no unscheduled holds. There were light southerly surface winds and some light clouds around the launch site but overall it was pretty clear. In the distance, some thunderstorms were observed near the launch time but they were no threat to the lift-off.

Apollo 11 was on its way at 09:32 EDT or 13:32 Greenwich Mean Time (GMT). Slowly at first, then quicker, in the first two and a half minutes of flight the Saturn V expended four and a half million pounds of propellant. Velocity has gone from zero to a little over 6,000 miles per hour. It was time for the second stage of the Saturn V to take over. Two minutes and 42 seconds after lift-off or Ground Elapsed Time (GET) the first stage was jettisoned and one second later the second stage engines were fired. The second stage drives Apollo up to 100 nautical miles with Mission Control marking each minute with a Go message for the astronauts. Nine minutes GET and the second stage had done its work and was released. The third stage took over almost immediately and would fire for two minutes and thirty seconds. For a few seconds after cut-off acceleration continued to enable Apollo to reach the required orbital velocity of 17,500 miles per hour. Apollo was now in an Earth orbit of 101.4 by 103.6 nautical miles above the ground.

Hello Eagle and Columbia

Although the pioneering days of spaceflight were naturally dramatic; in a strange sort of way the countdown and launch of Apollo 11 were uneventful, as would be the journey to the Moon and entry into lunar orbit. Nothing went wrong and everything went as planned. It could be argued it went even better than planned. The real drama however, was being stored for later.

The next important phase of the mission was the translunar injection burn. Two hours, 44 minutes and one-and-a-half revolutions of the Earth after launch the third stage of the Saturn V launcher was reignited for five minutes and 48 seconds. Apollo 11 reached an Earth escape velocity of 25,000 miles per hour and was on its way to the Moon. Next up was for the CSM to separate from the third stage of the Saturn V. This part of the rocket still contained the lunar module (LM) so the CSM turned and docked with the LM. The two spacecraft then separated from the third stage.

So far Collins had used Apollo's Reaction Control System for the maneuvers and now it was time for the Service Propulsion System (SPS) of the CSM to fire for the first time on the mission. It would be needed later to put Apollo 11 into lunar orbit and then to bring the astronauts home but this first use was to put distance between Apollo 11 and the spent rocket stage. The burn was successful and Apollo 11 moved away from the spent third stage of the Saturn V, which was left to enter solar orbit.

The CSM and the LM were each given their own names for use as callsigns. This was to help everyone know who was making contact when the spacecraft were apart from each other. The CSM was named 'Columbia' and the LM 'Eagle'. Columbia is a historical name and a symbol of the United States and Eagle is their national bird.

The translunar injection burn was so accurate that of the four planned mid-course corrections only the second, a three second burn of the SPS was required. It took about 73 hours to reach the Moon. At 17:22 GMT on 19 July 1969, the SPS was fired to place the spacecraft into lunar orbit. Mission Control had to wait to find out if the burn was successful as Apollo was on the far side of the Moon when it took place. Once in orbit the astronauts presented a live television transmission and conducted checks of the LM before settling down for a rest period.

An Alarming Interlude

Sleep, breakfast, checks, preparations and then it was time for the main event. Just over 24 hours after they entered lunar orbit Armstrong and Aldrin undocked the LM from the CSM. It was 17:44 GMT on 20 July 1969. Shortly after Armstrong radioed, *"The Eagle*

has wings." There were more preparations before descent orbit insertion was initiated by Armstrong at 19:08 GMT. This took place on the far side of the Moon and therefore again the astronauts were out of contact with Mission Control. The CSM was back in contact with Mission Control first but when it was time to reacquire contact with the LM there was no voice transmission. The data being received by Mission Control suggested all was well but why no contact. However, Columbia could speak to Eagle and so had to relay messages. Fortunately, the communication technicians on the ground quickly identified the problem before it could threaten the landing. Eagle's antenna was misaligned just a little. A message was relayed via Columbia to yaw slightly to one side and that seemed to do the trick.

That was the glitch over wasn't it? There has to be one but now it was done. No it was not, there would soon be more. The LM was at 50,000 feet off the lunar surface and started its powered descent at 20:05 GMT. Again communications dropped out. Collins relayed this to the LM and Aldrin switched to a different antenna restoring contact with Mission Control, which was just as well as a little over five minutes after the start of the powered descent the alarm sounded in the LM, *"Programme alarm,"* radioed Armstrong to the ground. Three seconds later he added, *"It's a 1202. Give us a reading on the 1202 programme alarm."* Fortunately, Steve Bales, Mission Control's lead specialist in LM navigation and computer software, had been involved in alarm simulations prior to the flight. A 1201 was not a reason to abort. Bales advised flight director Gene Kranz of this determination. Charlie Duke, later an Apollo 16 moonwalker but then an Apollo 11 CapCom, told the astronauts on the LM, *"We're Go on that alarm."* The alarm was caused by an overload in the LM onboard computer.

But it kept coming back! The 1202 alarm sounded twice more in the next four minutes. Bales and Duke gave the OK each time. Then there was a new alarm. This time it was Aldrin who made contact with Mission Control, *"Programme alarm. 1201."* This was the same type of alarm as a 1202 and would not stop the landing. Throughout the alarms, Armstrong's inclination was to keep going anyway as everything else was working fine. However, the alarms were a distraction from watching the lunar surface and hindering his search to find a suitable place to land. As Armstrong later noted, *"Most of our attention was directed inside the cockpit in this time period."*

As the LM dropped below 2,000 feet, Armstrong was finally able to fully concentrate on the lunar surface. What he saw was not good, *"Pretty rocky area,"* he reported to Mission Control. Aldrin later said the rocks were, *"as big as small motorcars."* At 500 feet, Armstrong took over manual control of the LM and slowed the descent to take them past the boulder field. He had seen a more promising area about a half-mile ahead. He was too busy to report what he was doing to Mission Control who were getting really anxious about the fuel situation.

The LM was 200 feet above the lunar surface when Duke radioed *"sixty seconds"* - meaning an estimated 60 seconds of fuel left. Duke takes up the story, *"When I called sixty seconds there was dead silence in Mission Control. You could certainly feel your heart beating. It was really getting critical. The tension was rising exponentially. I was talking a lot, just giving them updates from what we were seeing in Mission Control. Deke Slayton was sitting next to me: he kind of punched me in the side and said – shut up and let them land – Yes sir, boss!"* Slayton recalled the incident in his autobiography 'Deke', *"I did one thing I felt bad about after. Charlie Duke was talking too much when, really, the only thing that mattered now was what Buzz said. So I reached over and smacked him on the arm and said, 'Shut up'."* Slayton said that the tension *"was as bad as being in combat."* He had flown combat missions over Europe and Japan during World War Two, and whilst travelling by ship come under air and submarine attack, so he should know what he was talking about.

Armstrong thought that if they were below 100 feet then it was probably safer to continue and that if he could get to within forty feet of the lunar surface, perhaps even a bit higher, before he actually ran out of fuel then with the Moon's 1/6th gravity the LM could safely drop to a landing. There were two more calls that Duke could make on the fuel situation, 30 seconds and 'bingo' (bingo meaning land in 20 seconds or abort). Flight Director Kranz had already decided to give them every chance to land. The LM closed on the lunar surface. Duke remembers calling out *"thirty seconds"* and then Aldrin reported *"contact light"* meaning at least one of the three 68 inch sensory probes hanging down from the LM's landing legs had made contact with the lunar surface.

They were now far too low to abort safely and were close, very close. Armstrong was focused on the final few feet. Touchdown, it was 20:17 GMT (16:17 EDT) on 20 July 1969 or 102 hours and 45 minutes GET. Eagle had landed in the Mare Tranquillitatis (Sea of Tranquillity). Armstrong said *"Shutdown"* one second after touchdown. Aldrin added *"Okay. Engine stop."*

Telemetry was indicating less than twenty seconds of fuel remained although in reality there was probably a bit more. But at this moment nobody cared. Duke said, *"We copy you down Eagle."* Armstrong's reply came quickly, *"Houston, Tranquility Base here. The Eagle has landed."* Duke managed to get a reply out whilst all hell broke loose in Mission Control, *"Roger Twan… Tranquility. We copy you on the ground. You got a bunch of guys about to turn blue. We're breathing again. Thanks a lot."* There were cheers and US flags waved, hands shook as everyone in Mission Control released the tension of the preceding minutes. Somehow in the commotion Kranz was able to bring everyone's attention back to the job.

Checks were needed to confirm the LM could remain on the lunar surface and not require an emergency lift-off. The question was stay/ no-stay. The Mission Control team was unanimous: *"Stay Flight."* Armstrong and Aldrin had their own checks to make including preparations for a speedy lift-off if required. Once they were sure there would be no quick getaway thoughts turned to the next part of the mission.

What Day Is It

The pre-mission flight plan called for the astronauts to eat and then take a four hour rest period before moving on to EVA operations. Even before the mission the astronauts had doubts about whether it would be feasible to take a rest. Christopher Kraft, Director of Flight Operations, noted in his book 'Flight', *"Armstrong and Aldrin were too hyped to follow the flight plan and get some sleep…They wanted to get on with it."* Armstrong made a formal request to Mission Control who approved the change of plan. The astronauts would have a bite to eat and then get ready for the EVA.

In the meantime, Collins was in orbit eavesdropping on what was happening. He was not surprised by the decision to go for the EVA without a proper rest period. He had already thought Armstrong and Aldrin might go for this option. He knew it had been discussed before the flight. What happened next was more of a concern to him. Before he went out of contact behind the Moon, Mission Control advised him that there was a problem with the system for regulating the temperature of the coolant fluid. Mission Control provided him advice that would entail going through a lengthy malfunction process. Once he was out of contact with Earth he considered the problem. He wrote in his autobiography 'Carrying the

Fire' that if he followed Mission Control advice, *"It is an involved procedure and it seems like radical surgery to me. Instead, I simply check all my switch positions and flip the one which controls the offending temperature from automatic to manual, then back to automatic again."* The temperature returned to normal and when he was back in contact with Mission Control he reported that the problem had gone away.

Back on the Moon it turned out that getting ready for an EVA whilst actually on the Moon itself was much more difficult and time-consuming than in the simulations on Earth in the LM mock-up. Instead of two hours the preparations took three. Even the hatch opening took longer than expected due to residual pressure in the LM after venting. Finally the hatch was opened at 02:39 GMT on 21 July 1969 and this marked the start of the first Moon EVA. With different time zones around the World the date can be correctly recorded as either Sunday 20 July 1969 or Monday 21 July 1969. At the launch site in Florida it was 22:39 EDT on 20 July 1969 and in Birmingham, England, it was 03:39 British Summer Time (BST) on 21 July 1969.

Armstrong was first out of the hatch and then had to negotiate the ladder. It took him fifteen minutes from hatch opening to get into position at the foot of the ladder to step onto the Moon. He checked that he could get back up to the first rung of the ladder. He then returned to the bottom. *"I'm going to step off the LM now,"* Armstrong reported to Mission Control. Seven seconds later he did. It was 22:56 EDT on 20 July 1969 or 02:56 GMT (03:56 BST) on 21 July 1969, and 109 hours and 24 minutes GET. A small number of seconds later, Armstrong spoke those immortal words, *"That's one small step for man, one giant leap for mankind."* Or did he?

Armstrong would later say he intended to say 'one small step for a man' but might have missed out the 'a'. The 'a' cannot be heard on the recorded transmission but was it scrambled in static. Armstrong commented that, *"As I have listened to it, it doesn't sound like there was time there for the word to be there."* But, he could not state for a fact that he did or did not say the 'a'. Modern day analysis by professionals with experience of audio waveforms and audio spectrograms is not supportive of Armstrong saying 'a' but his words only makes sense if the 'a' is included and perhaps for posterity that is how it should be quoted.

The start of the EVA saw Armstrong give a description of the lunar surface and how he affected it whilst moving around. Aldrin then lowered the mission's seventy-millimeter Hasselblad camera down to him using the Lunar Equipment Conveyor (LEC).The astronauts nicknamed the LEC the 'Brooklyn Clothesline' because the idea came from the clotheslines on pulleys used outside the windows of apartments such as those often seen in Brooklyn, New York.

Armstrong took some photographs and Bruce McCandless, a rookie astronaut who years later flew on the Space Shuttle but then serving as a CapCom in Mission Control, dropped a hint about the contingency sample, *"We see you getting some pictures and the contingency sample."* In case of a sudden emergency requiring the astronauts to end the EVA the contingency sample was to ensure NASA had a sample of the lunar surface for study. Unsure if Armstrong had understood McCandless dropped a bigger hint, *"Did you copy about the contingency sample?"* Armstrong should have done this task before taking photographs. He said after the flight that he had not forgotten but he thought lunar surface conditions supported changing the order of tasks. *"I'm going to get to that just as soon as I finish these... picture series,"* Armstrong advised McCandless.

Armstrong completed the collection of the contingency sample thirteen minutes after his first step. Six minutes later Aldrin joined him on the lunar surface (03:15 GMT). It is possible that Aldrin gained a certain first at this point. He would later admit to relieving himself. Was this a first on another body of the solar system? Armstrong never disagreed. In looking around, Aldrin came up with the *"magnificent desolation"* phase that he would later use for the title of one of his autobiographical works. The EVA had less than two hours to run and they still had the ceremonial aspects of the EVA to complete as well as the more important aspects of the mission such as collecting samples and setting up scientific equipment.

Armstrong and Aldrin unveiled a commemorative plaque celebrating the first footsteps and then relocated the television camera to its final position about 60 feet from the LM. Aldrin then set up the Solar Wind Composition Experiment north of the LM. Next they had to place a US flag into the lunar surface, which proved easier said than done. Although most of their work on the lunar surface had been simulated in minute detail during their training, they had not practiced the flag deployment. They had difficulty extending the telescoping arm, which meant the flag could not be fully stretched out and then they had trouble penetrating the lunar surface deeply enough to keep the flagpole upright. They managed barely six inches into the ground and both astronauts worried about the public relations nightmare if the flag fell over in front of a global television audience.

Collins, orbiting the Moon in the CSM, was on the far side of the Moon when the EVA started. He came back in contact and asked, *"How's it going?"* McCandless replied, *"The EVA is progressing beautifully. I believe they are setting up the flag now."* Similar to Aldrin, what was to come shortly was a surprise to Collins.

Armstrong and Aldrin had spent a few minutes evaluating how to move around on the lunar surface when McCandless interrupted them and asked them to get *"in the field of view of the camera for a minute"* and after a pause added. *"Neil and Buzz, the President of the United States is in his office and would like to say a few words to you."* For Aldrin, this was a complete surprise. Deke Slayton had told Armstrong before the mission that there could be some special communication but did not say exactly what it would be. Nothing was mentioned to Aldrin or Collins. Armstrong replied to McCandless *"That would be an honour."*

President Nixon spoke: *"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. 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."*

Armstrong was quick to say, *"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 interests and the curiosity and with the vision for the future. It's an honour for us to be able to participate here today."*

Nixon replied, *"And thank you very much and I look forward...All of us look forward to seeing you on the Hornet on Thursday."* The Hornet was the aircraft-carrier that was tasked with recovering the Apollo 11 crew after splashdown. Aldrin was somewhat tongue tied but did manage an *"I look forward to that very much, sir."*

Science Takes Centre Stage

The two astronauts had about one hour and twenty minutes left to complete their EVA programme and get back in the LM. Armstrong started the bulk sample collection of assorted surface material and rock chunks. He went a little away from the LM for this as he wanted to make sure the samples had not been contaminated by the LM engine exhaust. Aldrin was busy carrying out evaluations of the effects of being on the Moon on visibility and the lunar excursion suit. Aldrin started an inspection of the LM and was joined by Armstrong. It was then time to get back to the science experiments.

The surface of the Moon at the landing site was full of bumps and hollows. The rugged nature was not conducive to finding a level spot to set up experiments. The astronauts did find a fairly level area south of the LM and set up the Passive Seismic Experiment Package (PSEP) and Laser Ranging Retro Reflector (LRRR) at about 60 feet and 80 feet respectively away from the LM. The PSEP was designed to measure seismic activity or 'Moonquakes' and meteoroid impacts to help analyse lunar structure. The PSEP was so sensitive that the early data sent back to Earth included Armstrong and Aldrin's footsteps as they continued the EVA. The LRRR was designed to measure the distance between the Moon and Earth by use of laser beams aimed from Earth. The astronauts had some difficulty setting up the two experiments but they got there in the end and the experiments were considered a great success.

McCandless then advised Armstrong *"We've been looking at your consumables, and you're in good shape. Subject to your concurrence, we'd like to extend the duration of the EVA one-five [15] minutes from nominal."* Armstrong agreed to this. He then decided to deviate from the flight plan, *"I didn't feel any restriction against violating a plan or drifting away from a plan somehow if the situation warranted,"* he said later. About 200 feet east of the LM was a small crater he had noticed just before touchdown. He thought there would be value in visiting 'Little West Crater' and photographing the area. He considered that it would make a worthwhile addition to the work they had already carried out rather than just doing the documented sampling activities he was due to start with Aldrin. He ran (in so far as you can in 1/6th gravity whilst wearing a bulky EVA suit) there and back and obtained eight photographs of the area. He was away from the vicinity of the LM for a little over three minutes.

The astronauts time on the lunar surface was short by now. Armstrong collected a few more lunar samples using a pair of long-handed tongs and Aldrin had to hammer a metal tube into the ground to obtain a core sample. This proved as difficult as planting the US flag and Aldrin had to use considerable force to get the tubes in the ground, *"I hope you're watching how hard I have to hit this into the ground to the tune of about five inches,"* he said to McCandless. A few minutes later McCandless told Aldrin he had three more minutes before he had to start packing up or as McCandless put it, *"commence your EVA termination activities."* Aldrin retrieved the Solar Wind Composition Experiment. It had been exposed on the lunar surface for 77 minutes and had collected ions of helium, neon and argon. Studies by scientists on Earth of this experiment would expand our knowledge of the origin of the solar system, the history of planetary atmospheres and solar wind dynamics.

Everything to be carried back to Earth was brought to the foot of the LM ladder, including the solar wind experiment, lunar surface samples and film cassettes. *"Anything more before I head up Bruce?"* Aldrin asked McCandless. *"Negative. Head up the ladder Buzz,"* McCandless replied. So he did and made his way into the LM. Armstrong continued with 'EVA termination activities'; he closed the sample boxes for which he had to use some force, and had to carry to and load the LEC with the items to be returned to Earth. This period involved Armstrong in some pretty intensive physical activities and Mission Control recorded his heart rate rising to 160 beats per minute. His normal rate when not exercising was usually about 60. During the EVA Aldrin's heart rate had peaked at 105. McCandless said, *"Neil, this is Houston. Request an EMU check. Over."* This was a ruse to get Armstrong to slow down. The EMU is his spacesuit or Extravehicular Mobility Unit. Armstrong provided Mission Control with some readings off his EMU indicating the suit was functioning fine. This check has the added bonus of slowing Armstrong down and reducing his heart rate.

The astronauts continued with loading the samples into the LM. With this concluded Armstrong asked Aldrin, *"How about that package out of your sleeve?"* In his autobiographical works Aldrin incorrectly puts the timeline for this as being half-way up the ladder on leaving the lunar surface and before the samples were loaded for return to Earth rather than after but this is an excusable error as it was a busy EVA. Aldrin related part of the story in his Magnificent Desolation book as he explained that after the reminder, *"I realised that in our excitement, I had indeed forgotten something --- something extremely important to Neil and me. I reached into my pocket and pulled out the small pouch that I had carried with me in my spacesuit while on the Moon."* Aldrin took a last look at the pouch and then tossed it towards the lunar surface. It landed by Armstrong who straightened it out a little with his boot.

The package contained two Soviet medallions in honour of Soviet cosmonauts Vladimir Komarov and Yuri Gagarin, an Apollo 1 patch commemorating US astronauts Virgil Grissom, Edward White and Roger Chaffee, and a small gold olive-branch pin - a symbol of peace. Komarov had died when he crashed at the end of the Soyuz 1 spaceflight in 1967 and Gagarin was killed in an aircraft training flight in 1968. Grissom, White and Chaffee had perished in the Apollo 1 fire during training on the launch pad in 1967.

At 05:09 GMT on 21 July 1969, Armstrong left the lunar surface and joined Aldrin in the LM. The hatch was closed at 05:11 GMT. The first Moon EVA had lasted 2 hours, 31 minutes and 40 seconds. Armstrong and Aldrin used up the rest of their film taking photographs before having a meal break. About two and a half hours after the EVA ended the LM was depressurised again to enable the astronauts to discard rubbish and equipment they no longer needed such as their spacesuit EVA backpacks. Armstrong and Aldrin had collected almost 48lb of lunar material and of course the more weight the LM carried meant more fuel used to get back into orbit, so any weight saved was useful to conserve fuel in case of difficulty after lift-off. It also had the side-effect of de-cluttering the LM. The PSEP actually picked up the backpacks impacting on the lunar surface. The hatch was then closed for a final time. There were some questions from Mission Control, a sort of limited debrief, before the astronauts could settle down for a much earned rest period.

Armstrong and Aldrin did not sleep well despite the long and exhausting day they had gone through. They had been awake for nearly 22 hours but found it difficult to unwind after the excitement of the day. It was also not very comfortable in the LM. It was not configured to act as a bedroom and there was a high-pitched whine from the coolant pumps. It was also unexpectedly cold. Collins on the other hand slept soundly as he orbited the Moon. Collins was woken by CapCom Ron Evans about five hours after Armstrong and Aldrin had settled down. Three years later Evans took on the CMP role for Apollo 17 (the last lunar landing mission). About 41 minutes later (at 15:12 GMT) Evans made a similar call to Tranquility Base. Armstrong and Aldrin quickly busied themselves with preparations for lift-off, which was less than three hours away.

The Eagle Has Wings

During the time the LM had been on the lunar surface Collins was in orbit making scientific observations and taking thousands of photographs. He also tried to identify by sight where the LM had landed but was unable to do so despite repeated attempts. Now it was nearing the time when he would see them again, he hoped. *"I have never sweated out any flight like I am sweating out the LM now,"* he said in his autobiography. *"My secret terror for the last six months has been leaving them on the Moon and returning to Earth alone: now I am within minutes of finding out the truth of the matter."*

Back on the Moon Aldrin was on countdown duties, *"9, 8, 7, 6, 5, Abort Stage, Engine Arm, Ascent, Proceed."* 17:54 GMT 21 July 1969. Moments later Aldrin added, "We're off." Several seconds later Armstrong commented, *"The Eagle has wings."* The ascent stage engine was fired for 435 seconds. Once in lunar orbit the LM made several burns to rendezvous with the CSM. Collins took photographs of the approaching LM including some showing the Moon, the Earth, the LM and errr… the window frame of the CSM.

Armstrong then decided to deviate from the flight plan and make an unplanned attitude adjustment. The two spacecraft were about 50 feet apart but Armstrong knew if the flight plan was followed they would be looking directly into the Sun. This would make for unsatisfactory lighting conditions for docking. Armstrong explained what happened next in technical debriefings after the spaceflight was over.

"So the alternative would be to roll the LM 60 degrees, pitch down, and then you'd be in the same attitude and would have prevented the Sun coming into the window. After arriving at that attitude, a discussion between the LM and the Command Module indicated that we weren't quite far enough, so I rolled a little farther, pitched over, and waited looking through the top window. We were asked to rotate a little farther by the Command Module to line up the docking aids and get the proper alignments. We complied and promptly manoeuvred the vehicle directly in the gimbal lock. I wasn't aware of it because I was looking out the top window. No doubt, we were firmly ensconced in gimbal lock. We had all the lights on, the DAP was not operating anymore, we had no control outputs, clearly no CDU outputs were being processed, so we just put it in AGS and completed the docking in AGS."

Aldrin noted that, *"And I don't think the AGS is a good system to dock in."* Aldrin's comment may have been related to what happened shortly after docking. Armstrong continued his explanation. *"This was just a goof on our part. We never should have arrived at the conclusion from any series of manoeuvres. However, that's how it happened. It wasn't significant in this case, but it certainly is never a desirable thing to do. There's nothing catastrophic about it here, but I'm sorry that somehow or other we hadn't studied the docking manoeuvre a little bit more carefully and recognized that there might be some attitude constraints in the manoeuvre that we hadn't considered."*

The post-flight technical debrief was a time for the astronauts to overdose on acronyms. In the comments made by Armstrong and Aldrin in the previous paragraphs several are used that are new to this article: AGS = Abort Guidance System, DAP = Digital Autopilot and CDU = Coupling Data Unit. There is also the term 'gimbal lock' – very basically this meant that the LM did not know where it was. Normally that would require a time-consuming procedure to put it right but because they were already where they should be and the CSM would become the active spacecraft for docking no corrective action was needed. But using AGS had an unforeseen consequence.

Collins piloted the CSM towards the LM. Armstrong told Collins, *"I'm not going to do a thing, Mike. I'm just letting her hold in Attitude Hold."* Over the next two and a half minutes the CMP closed on the LM. Docking came at 21:35 GMT. The two spacecraft had achieved a soft dock, which means they are linked but not fully connected. Until they are fully connected, known as a hard dock, the astronauts cannot transfer from the LM to the CMP through the internal tunnel. Collins flicked the switch to start the retraction cycle of the docking mechanism to achieve the hard dock. He got, *"the surprise of my life!"* he noted in his autobiography. *"Instead of a docile little LM, suddenly I find myself attached to a wildly veering critter that seems to be trying to escape."*

As a result of the gimbal lock the LM was holding its attitude using the AGS. When Collins started the docking probe retraction process the AGS sensed an attitude change and began to fight it. The CSM went to an about 15 degree yaw right angle and Collins took manual control to yaw back over towards the centreline. But there were more oscillations. Collins was worried they would not get a hard dock. This would mean he would have to release the LM and if nothing was damaged try to dock again. Even if docking could not be achieved there was a back-up plan involving Armstrong and Aldrin spacewalking between the two spacecraft with their Moon rock sample boxes attached and floating with them. Collins got back to the centreline and 'bang', the docking latches fired and the two spacecraft were hard docked. Despite everything that had happened only six to eight seconds had actually elapsed from the time Collins threw the retraction switch to the point of hard dock.

Collins carried out checks before moving into the tunnel to open the hatch. He removed the docking equipment so the LM astronauts could return to the CSM with their goodies (a non-technical term for Moon rocks, dirt, film magazines etc). Items that were no longer needed, such as the docking equipment, were loaded into the LM. Whilst they are on the far side of the Moon, Armstrong and Aldrin transfer to the CSM and the hatch is closed

Duke had now returned to CapCom duties having taken over from Evans. At 23:38 GMT, Duke said *"Columbia, Houston. You can undock at your convenience, correction, jettison at your convenience."* He corrected himself because the two spacecraft were not undocking. The LM and the docking ring at the top of the CSM were to be cut away using an explosive charge. The docking ring had to be removed because it would otherwise affect the CSM's centre of mass and therefore its flying characteristics upon re-entry.

At 23:41 GMT, Collins flicked the necessary switches. There was a small bang and the LM ascent stage was jettisoned. Collins was glad to see the back of it. As he related in his autobiography, *"the whole goddamned LM has been nothing but a worry for me and I'm glad to see the end of it."* He does however acknowledge that, *"Neil and Buzz, on the other hand, seem genuinely sad: old Eagle has served them well…"* Just over 20 minutes later, Collins fired the RCS for several seconds to move the CSM away from the LM.

The Get-Us-Home Burn

The CSM continued to orbit the Moon whilst the crew prepared for the next major event of the mission. This is the Trans-Earth Injection burn that is to take Apollo 11 out of lunar orbit for its journey home. Collins had some colourful phrases for it, *"the get-us-home burn, the save-our-ass burn, the we-don't-want-to-be-a-permanent-moon-satellite burn."* Like the arrival burn, this one would also take place whilst Apollo is hidden from the Earth by the Moon. The CSM had completed its 30th and final orbit of the Moon.

At 04:55 GMT on 22 July 1969, the SPS was fired. The burn lasted for two and a half minutes. About six minutes after the burn ended

Apollo 11 came back into contact with Mission Control. The data feeds first and then Duke at the CapCom station started to talk to the crew, *"Hello Apollo 11. Houston. How did it go? Over."* Collins replied, *"Time to open up the LRL doors, Charlie."* The LRL doors was a reference to the Lunar Receiving Laboratory (LRL), which was a quarantine facility that was to become the astronauts home on Earth for a time. Duke added, *"Roger. We got you coming home. It's well stocked."* The Apollo 11 crew took lots of photographs of the receding Moon and this continued for some time as all three astronauts took turns.

At 06:24 GMT on 22 July 1969, there was a temporary change of CapCom. Deke Slayton called the crew, *"This is the original CapCom. Congratulations on an outstanding job. You guys have really put on a great show up there. I think it's about time you powered down and got a little rest, however. You've had a mighty long day here. Hope you're all going to get a good sleep on the way back. I look forward to seeing you when you get back here. Don't fraternize with any of those bugs en route, except for the Hornet."* Armstrong replied, *"Okay. Thank you, boss. We'll - We're looking forward to a - to a little rest and a restful trip back. And see you when we get there."* Slayton signed off with, *"Rog. You've earned it."*

Slayton's referencing to being the original CapCom was both accurate and not accurate. He was the CapCom in Mercury Mission Control for the first US spaceflight in 1961. However Gordon Cooper also performed CapCom duties from the Blockhouse prior to lift-off. Cooper handed over to Slayton 15 seconds before lift-off.

It would still be another hour and a quarter before the Apollo 11 crew could settle down for a rest period. They continued to take photographs, carry out actions as directed by Mission Control and answer questions from them. Another long day finally came to an end but instead of the fitful sleep periods that had been the recent norm they would all fall into a deep sleep. Each of the astronauts got at least eight hours sleep. It was the most satisfying sleep of the entire flight.

By the time they awoke, they were two days and two sleep periods away from Earth. The flight plan called for three mid-course corrections on the way back but mirroring the journey to the Moon only one was required. There were two more television transmissions during the trans-Earth coast and there was plenty of housekeeping that kept the crew busy. However, the intensity of the flight had eased. There were of course the inevitable questions from the ground to be answered regarding various aspects of the mission but there was also time for a little fun.

There was a little over 40 hours to go on their return journey when some strange sounds were heard in Mission Control. There was an exchange about the sounds between CapCom and Apollo. Duke asked, *"Apollo 11, Houston. You sure you don't have anybody else in there with you?"* Collins said, *"Houston, Apollo 11. Say again, please."* Duke said, *"We had some strange noises coming down on the downlink, and it sounded like you had some friends up there."* Collins changes the subject but about five minutes later there were further odd shrieking sounds on the downlink.

The Public Affairs Officer said of the situation, *"This is Apollo Control. Still no explanation [for] the weird noises emanating from Apollo 11, if indeed it is from Apollo 11 and it's reported from Network that it's being received on the downlink at two different stations in the Manned Space Flight Network. Perhaps it will all shake out later in the mission as to what these strange noises are."* There was a lack of further comment at the time but later Collins revealed what was going on. The astronauts were having a bit of fun with the ground.

They had taken some music tapes with them and they also had a tape with strange noises, *"a jangling cacophony of bells, whistles, shrieks and unidentifiable sounds,"* Collins noted in his autobiography. *"We amuse ourselves now by pushing our radio transmitter button and holding the screeching tape recorder next to a microphone."* Collins admitted that when Duke asked if they had company he was pretending to have not heard him.

On their penultimate day in space they made their final television broadcast and kept up with housekeeping duties etc. After the television broadcast Collins was told his biomedical telemetry was not working. He checked out the sensors attached to his chest but could not get them to work. He was not a fan of these sensors and rather flippantly told the ground, *"Well, I promise to let you know if I stop breathing."*

Sorry Mr President for Landing Short

They were within half-an-hour of their final sleep period when Duke came on air, *"…And I got a couple of other things, Mike. We need to terminate Battery B charge at this time, and also, the weather is clobbering in at our targeted landing point due to scattered thunderstorms. We don't want to tangle with one of those, so we're going to move you - your aim point up-range. Correction, it'll be down-range, to target for a 1,500-nautical-mile entry, so we can guarantee uplift control. The new coordinates are 13 degrees, 19 minutes North; 169, 10 minutes West. The weather in that area is super. We got 2,000 scattered, 8,000 scattered with 10 miles visibility and 6-foot seas and the Hornet is sitting in great position to get to that targeted position."* Collins acknowledged the call.

During a normal Apollo re-entry, the spacecraft travels about 1,200 nautical miles between the 0.05g point and splashdown. This profile does not require the spacecraft to perform a skip-out manoeuvre. In order to miss the weather system Apollo 11 must perform a skip-out in order to stretch the entry path further downrange toward Hawaii to a new splashdown point. Pre-flight Collins had not had time to practise this type of re-entry. If the computer does its job properly then all is well but if it does not and he had to take manual control then that produced additional difficulties. As he explained in his autobiography, *"To get that extra range will require a great soaring arc after our initial penetration into the atmosphere, and the difference between soaring an extra 215 miles and skipping out of the atmosphere altogether is slim indeed."* His conclusion is that, *"I may just land short, whether or not it disappoints or embarrasses President Nixon on the Hornet."*

Their final day started a little under six hours from splashdown. After breakfast Mission Control went through the procedures that Collins would follow if he had to take manual control. CapCom Evans told Collins, *"Okay, Mike. Of course, this is in the event the G&N and the EMS quits and you have to fly the constant-g; and what we're trying to do is to extend the constant-g range from 1,100 to 1,500 miles. We've run this procedure in the simulator, and it works fine. Basically, I'll go through it - just go through it, and then if you have any questions, come back. But it's the same lift vector up until Max g, and then lift vector down, and then modulate the lift vector until g-dot goes to zero. Okay, this procedure is essentially the same so far. And then hold g-dot zero until you pass the Retro elapsed time of V-circular; and then after you pass this Retro elapsed time of V-circular, roll to a gimbal angle of 45 degrees, and then hold this constant bank angle of 45 degrees until you come to the Retro elapsed time of drogues. Over."*

Collins replied, *"It sounds straightforward enough. Understand constant-g backup - back-up procedure, lift vector up until Max g and then lift vector down, then modulate until bank angle - until g-dot equals zero.*

Maintain g-dot equals zero until subcircular, then roll 45 degrees and hold until drogue time. Over." Evans responded with, *"Okay. That's mighty fine, Mike. That's correct."* But as Collins explained in his book, *"Mighty fine, my ass; if I have to fly it that way, I guarantee I won't come down in sight of the boat."* The computer had worked flawlessly so far so he is hopeful that he will not have to take over. As Armstrong later reported at the post-flight technical debrief, *"The computer did its usual brilliant job at steering."*

At 16:21 GMT on 24 July 1969, the Service Module was separated from the Command Module. Re-entry was now just minutes away. Re-entry proper started at 16:35 GMT as a deceleration of 0.05 g is sensed. There was a communications blackout as the spacecraft was surrounded by ionised gases created by the heat of re-entry. The ionized air blocks radio signals. At 16:38 GMT, the Command Module is spotted by an Apollo Range Instrumentation Aircraft. Six minutes later and the main parachutes were deployed at about 10,000 feet. The astronauts felt a small jolt. At 16:49 GMT, Armstrong reported, *"Apollo 11 at 1,500 feet."*

Recovery helicopter using callsign Swim 1 called it, *"Splashdown! Apollo has splashdown."* It was 16:50 GMT (12:50 EDT) on 24 July 1969. GET was 195 hours and 18 minutes. Apollo 11 had splashed down in the Pacific Ocean 13 nautical miles from the recovery ship USS Hornet. The Command Module settled into what NASA called the Stable 2 position, which meant not quite upside down. Inside the Command Module the astronauts pumped up floatation bags and after several minutes Stable 1 (or fully upright) was achieved.

Watch Out For Bugs

The recovery helicopter dropped frogmen who installed a floatation collar and attached a large raft. Biological Isolation Garments (BIG's) were delivered, one for a frogman and three for the astronauts. The hatch was opened and three BIG's were thrown in for the astronauts. The astronauts and the Command Module were cleaned with disinfectant to protect the Earth from harmful lunar organisms. Collins, as is usual for him, had his own humorous take, *"No lunar bugs can survive such a bath, we like to believe, although what prevents them from escaping into the sea I don't really know."*

It was just over an hour after splashdown that the astronauts arrived on the USS Hornet to be delivered to the Mobile Quarantine Facility (MQF). President Nixon welcomed them home as they looked through a window in the MQF. The USS Hornet sailed to Pearl Harbor and arrived on 26 July 1969. The MQF was loaded onto a flatbed truck and driven to Hickam Air Force Base from where they were flown to Ellington Air Force Base, Houston, in a Lockheed C-141 Starlifter,

They arrived at Ellington around midnight local time but there were problems loading the MQF onto another flatbed truck. It took three attempts prompting NASA Flight Surgeon Dr Bill Carpenter, who was accompanying the astronauts, to quip, *"They can send men safely to the Moon and back, but they can't get the men off the airplane."* They were then driven to the Manned Spaceflight Center (renamed the Johnson Spaceflight Center in 1973) and delivered to the LRL.

It was Armstrong's 39th birthday (5th August) whilst they were in the LRL and the LRL chef surprised him with a cake. The quarantine period ended at 21:00 local time on Sunday 10 August 1969. These quarantine procedures were followed for the next two Moon landings, Apollo 12 (1969) and Apollo 14 (1971) before it was decided there was no need to continue as there was no danger from lunar germs.

There were six Moon landings during the Apollo Programme with the last in 1972. As we look back 50 years at the first it is with some surprise and regret that the dreams of visiting other bodies in our solar system were lost through political expediency and a lack of imagination from those we naively put in positions of power to further our hopes and expectations.

Notes, acknowledgements and sources:

All lift-off and landing (splashdown) dates are given in GMT unless otherwise stated.

Air Force Space and Missile Museum website; A Man on the Moon ©1994 by Andrew Chaikin; Apollo: The Definitive Sourcebook ©2006 by Richard W Orloff and David M Harland; Apollo 11: Moon Landing ©1989 by David J Shayler; Apollo 11: The NASA Mission Reports Volume One ©1999 edited by Robert Godwin; Carrying the Fire ©1974 by Michael Collins; Collect Space; Countdown ©1988 by Frank Borman with Robert J Serling; Deke! US Manned Space From Mercury to the Shuttle ©1994 by Donald 'Deke' Slayton with Michael Cassutt; First Man ©2005 by James R Hanson; Flight: My Life in Mission Control ©2001 by Christopher C Kraft and James L Schefter; How Apollo Flew to the Moon ©2008 by W David Woods; In the Shadow of the Moon ©2007 by Francis French and Colin Burgess; Magnificent Desolation ©2009 by Buzz Aldrin with Ken Abraham; Men From Earth ©1989 by Buzz Aldrin and Malcolm McConnell; NASA, and its various centres and websites; Return to Earth ©1973 by Edwin E 'Buzz' Aldrin with Wayne Warga; *Spacefacts; Timeanddate.com;* Who's Who in Space ©1999 by Michael Cassutt; Wikipedia.

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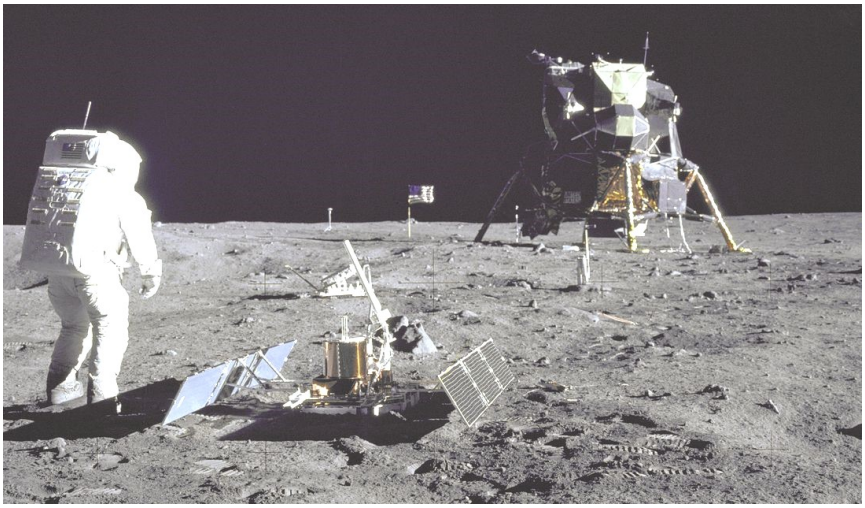

Apollo 11 Astronaut Buzz Aldrin stands on the moon beside seismic measurement gear, part of the Early Apollo Scientific Experiments Package. To the right is the lunar module Eagle.

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The Making of the Apollo 11 Mission Patch

Following the tradition set by the crew of Gemini V, the Apollo 11 crew was given the task of designing its mission patch. Apollo 11 was, and still is, one of the most publicly recognized missions NASA has ever had. The eyes of the world were on Neil Armstrong, Buzz Aldrin and Michael Collins, making the Apollo 11 patch not only be a symbol for the mission, but also a representation of the intentions of America, the hopes of NASA, and the astronauts themselves. With this daunting task in front of them, the astronauts set forth to create a design. After some discussion the crew decided to keep their names off the patch. Michael Collins explains: "We wanted to keep our three names off it because we wanted the design to be representative of everyone who had worked toward a lunar landing, and there were thousands who could take a proprietary interest in it, yet who would never see their names woven into the fabric of a patch. Further, we wanted the design to be symbolic rather than explicit."

In addition to keeping the crew names off the patch, the decision to use the Arabic numerals "11" instead of "XI" or even "eleven" was extremely purposeful. Neil Armstrong particularly disliked spelling out the word "eleven" (as it was in Collin's first design), because it wouldn't be easily understandable to foreigners, so the crew decided on "11".

Fellow astronaut Jim Lovell suggested the eagle, the national bird of the United States, as the focus of the patch. Running with that proposal, Michael Collins found a picture of an eagle in a National Geographic book about birds: *"Water, Prey, and Game Birds of North America,"* and traced it using a piece of tissue paper. He then sketched in a field of craters beneath the eagle's claws and the earth behind its wings. This preliminary design did not satisfy the crew. Armstrong and Collins believed that it did not represent all they wanted it to convey. The olive branch was suggested by Tom Wilson, a computer expert and the Apollo 11 simulator instructor, as a symbol of the peaceful expedition. The crew was delighted with that notion and Collins quickly modified the sketch to have the eagle carrying the olive branch in its beak.

After making a few detail-oriented decisions, the patch was ready to be submitted. Highly realistic, the crater-pocked moon was colored grey, the eagle brown and white, the Earth blue, and the sky black (just as it would be from the lunar surface). The Earth, suspended like a small blue marble in a black sky, is actually incorrectly drawn. The patch shows the Earth to be shadowed on the left side, while the Earth, if viewed from the lunar surface, would be dark on the bottom. This mistake was never corrected.

However, the initial patch design was rejected. Bob Gilruth, the director of the then-named Manned Spacecraft Center, saw the eagle landing with its talons extended as too hostile and warlike. So, the olive branch was transferred from the eagle's mouth to his talons, a less menacing position. Although happy with the design, Michael Collins maintained that the eagle looked "uncomfortable" in the new version and that he "hoped he dropped the olive branch before landing".

The Final Design

The embroidered Apollo 11 patch was manufactured by A-B Emblems, a patch embroidery company started by E. Henry Conrad. A partner of NASA for previous missions, A-B Emblems became the sole contractor for all NASA patches in 1971.

It was a common practice for the commander of each mission to fly a T-38 into the Asheville airport to help the designers achieve the vision of the crew. Once the graphic was approved, a drawing would be created of the design. The drawing would then be blown up, using scale rulers and enlarging cameras, to exactly six times the size of the patch. The enlargement would be marked with a pencil to show every embroidery stitch required for the final product. The sketch would then be fed into the punching machine, which would produce a roll of paper with punches for every stitch. As the final step before embroidery, the Swiss Embroidery Loom would be threaded and the punching roll is fed into it along with the cloth. After the machine (with the help of a human hand) was finished embroidering, the emblems were cut and given a triple-thread pearl stitch border in order to insure that it is ravel proof.

The embroidered patches are sewn onto flight suits, recovery suits, jackets, and any other official NASA gear for the mission. The spacesuits themselves did not have embroidered patches. Instead, the patch would be silkscreened directly onto the fabric along with the NASA logo and the American flag.

From the Moon to Mars:

On July 20, 1987, Neil Armstrong, Buzz Aldrin, and Michael Collins signed a silk-screen patch flown aboard Apollo 11 and presented it to former NASA Administrator James C. Fletcher for safekeeping. The inscription of the patch reads: "Carried to the moon aboard Apollo XI, Presented to the Mars I Crew."

Looking forward into the future, it seemed only appropriate that a patch, which witnessed mankind's first giant leap, should be there for its second.

Cat Baldwin

Summer 2016 NASA History Office Intern

https://www.nasa.gov/feature/the-making-of-the-apollo-11-mission-patch

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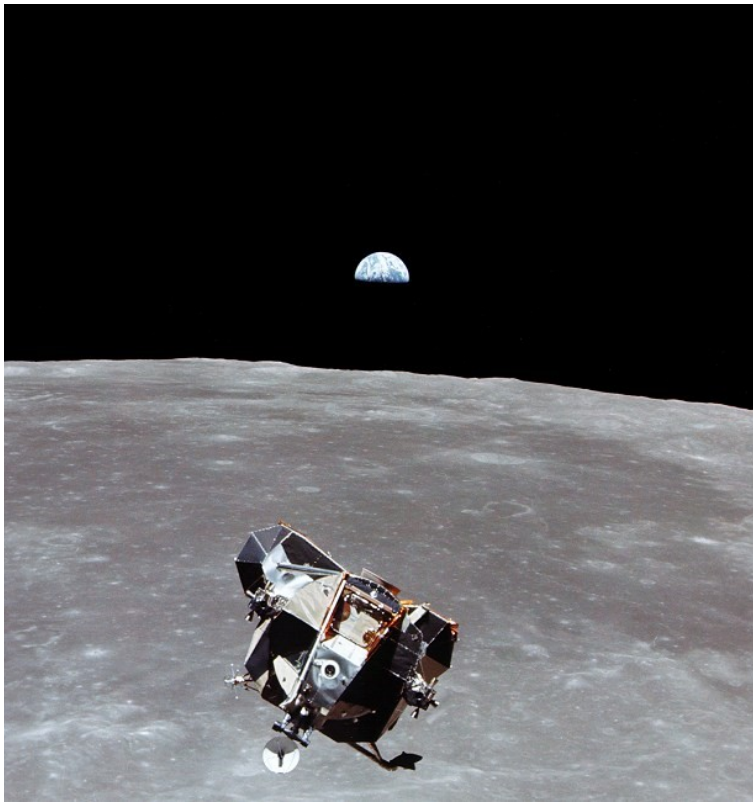
Armstrong in Lunar Module after historic moonwalk.

Picture taken by Buzz Aldrin, NASA. www.nasa.gov



This iconic picture of the Lunar Module approaching the Command and Service Module encompasses all of the people of Earth, except one, the photographer, Astronaut Michael Collins.

www.nasa.gov

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Copy Deadline

All contributions intended for the September—October 2019 issue should be emailed to the editor by **Friday 9 August 2019**