

Hi this is Steve Nerlich from Cheap Astronomy www.cheapastro.com and this is *Apollo 11 – The Landing*.

This is the second of three podcasts on the Apollo 11 mission celebrating the 40th anniversary of the first Moon landing.

We last left the intrepid Apollo 11 adventurers completing their TLI, or translunar injection manoeuvre which put them on a trajectory to the Moon with the third stage of the Saturn V rocket, now almost empty of fuel, still attached.

At three hours and fifteen minutes after launch, the Apollo 11 command module, also known as Columbia, detached from the Saturn V third stage, did a quick 180 degree turnaround and docked with the Lunar Module, also known as the Eagle, that was sitting within a bay at the top of the third stage. Having extracted the lunar module, Mission Control in Houston sent a signal to the Saturn V third stage to burn its residual fuel to put it into a solar orbit, where it may still be today.

The now co-joined command module Columbia and lunar module Eagle then continued on their 3 day journey to the Moon, making only one course correction manoeuvre in the second day of their voyage – requiring a three second burn of the SPS – or Service Propulsion System – engine. The SPS is at the back of the service module – the other substantial component of the Apollo spacecraft. The service module is not accessible by the crew, but carries vital components like the SPS engine, as well as hydrogen and oxygen fuel cells which are used to produce electric power – and drinking water as a by-product.

On its journey to the Moon, the Apollo 11 spacecraft steadily decelerated from an initial 10.8 kilometres a second to only 1.5 km kilometres a second – without expending any fuel due to the drag of the Earth's gravity. But, as they approached the Moon, its gravity begins to speed them up again towards 2.5 kilometres a second and they need to fire the SPS engine again to slow themselves down enough to enter a stable lunar orbit at a speed of about 1.6 kilometres a second. So on the 19th July, the third day since launch, the SPS engine fires for nearly 6 minutes to achieve Lunar Orbit Insertion – which like everything else so far, goes flawlessly.

And then, during Apollo 11's second orbit of the Moon, the Lunar Module, with Armstrong and Aldrin aboard, undocks leaving Michael Collins behind in the command module.

The lunar module is a whole separate spacecraft which has itself has two parts, the descent stage and the ascent stage. The descent stage is the base of the spacecraft with four spindly legs and the descent engine – which is arguably the most complicated component of the whole suite of Apollo engineering systems. The descent engine needs to be ignited in a microgravity vacuum – and rather than just delivering an on/off rocket blast, needs to be throttle-controlled to allow the spacecraft to descend slowly, but also hover just over the surface while the crew tries to find a landing site.

And as Armstrong and Aldrin began their descent things started getting interesting. They began getting 1202 and 1201 program alarms which meant the navigation and guidance

computer was overloaded. Mission Control checked it out and told them the alarms could be ignored, but then a real worry starts to emerge.

It so happens that the density of the Moon's crust is quite variable – there are mass concentrations or Mascons – which can generate local gravitational anomalies sufficient to perturb the orbit of a spacecraft.

Tom Stafford, the commander of Apollo 10, who had flown over the proposed Apollo landing site (ALS 2) had advised that the landing site was good – as long as they didn't stray downrange where a rough boulder field would probably require them to abort the landing. However, due to the perturbing effect of Mascons, as the Eagle approached the surface it became clear that they had strayed way downrange.

Armstrong, who despite Buzz Aldrin's designation as Lunar Module Pilot, was actually flying the Eagle, assumed manual control to first overfly a particularly treacherous looking crater named West Crater, then a smaller one named Little West.

And then because hey, it's Neil Armstrong – he did find a spot to settle the Eagle down, just past Little West's debris field and a bit after 8.15 pm Greenwich Mean Time on the 20th of July 1969, he announced "ah Houston, Tranquillity base here, the Eagle has landed".

A scheduled sleep break was skipped, but it still wasn't until 2am on the 21st of July (but still 11pm on the 20th of July on the east coast of the USA) that Armstrong descended the ladder. Armstrong claims that he composed the 'one small step' speech without assistance during the flight to the Moon. Many a PhD thesis has been developed around whether or not he said 'one small step for (a) man...'. Armstrong himself has indicated that whether or not the (a) was uttered, the intention was there – and has since requested the (a) be represented in brackets in any written transcript. Cheap Astronomy has made it so for the transcript of this podcast.

Buzz Aldrin then followed and made his historic 'magnificent desolation' comment about the Moon's appearance – and then they both got to work, setting up experiments, including the collection of 22 kilograms of moon rock and regolith.

Aldrin set up the Solar Wind Collector, a sheet of aluminium foil (sorry aluminum) that would pick up high energy particles radiating out from the Sun, which are otherwise deflected away from the Earth by our magnetic field. Meanwhile Armstrong unpacked the sample return containers for the rocks and the regolith – and it's him you can see running back and forth in front of the TV camera they set up on the surface.

But before they could get anything more done – the phone rang and it was Richard Nixon. After that, they began to unpack experiments that would remain on the Moon after they left, notably the solar powered Passive Seismic Experiment which remained operational for nearly a month after they left – and the Laser Ranging Retro Reflector – which remains in operation today, along with other LRRRs set up by Apollo 14 and Apollo 15. Essentially just a mirror, an LRRR allows a very exacting measurement of distance between the Earth and the Moon by bouncing back a laser beam that has been fired from Earth.

The easily detectable presence of the LRRRs might be considered incontrovertible evidence that Man really did fly to the Moon – but still for some people, nah.

In the last stages of the moonwalk, while Aldrin attempted to collect deep rock core samples, Armstrong took a lengthy stroll nearly 60 metres from the Eagle to take a panorama shot. And just before boarding the Eagle he left a collection of memorial items, allegedly one of Yuri Gagarin's medals and one of Vladimir Komarov's who died in space aboard Soyuz 1 – as well as mementos of the Apollo 1 astronauts, Grissom, White and Chaffee who died testing a prototype of the command module that had brought the Apollo 11 crew to the Moon.

Returning inside the Eagle, after 4am Greenwich Mean Time, Armstrong and Aldrin then remained on the Moon's surface for a well earned rest until nearly 6pm on the 21st of July 1969 – but of course their return is the subject of part 3 of this podcast trilogy.

Thanks for listening. This is Steve Nerlich from Cheap Astronomy, www.cheapastro.com. Cheap Astronomy offers an educational website in peace, for all mankind – as long as it doesn't cost too much. No ads, no profit, just good science. Bye.