Hi this is Steve Nerlich from Cheap Astronomy www.cheapastro.com and this is *Apollo 11 – Getting back again.*

This is the third of three podcasts on the Apollo 11 mission, the first Moon landing.

In the last episode, Neil Armstrong and Buzz Aldrin, landed safely on the Moon, spent nearly 7 hours preparing for a moonwalk, did the moonwalk for two and a half hours and then stayed on the surface for another 12 hours, to sleep and then prepare for liftoff just before 6pm on the 21st of July 1969. Preparations included throwing out the trash – like their spacesuit backpacks and anything else that represented disposable weight.

You may recall that the Lunar Module has two parts – the descent stage, with its descent engine, and the ascent stage, with its own ascent engine which will launch the craft straight off the top of the descent stage. The spacecraft will fly straight up for 18 kilometres and then follow more of an orbital path to an altitude of over 80 kilometres when it can dock with the command module, Columbia – with Michael Collins aboard.

If you've ever seen a lunar module launch from the Moon's surface – and if you haven't, see the show notes – you will appreciate what a remarkable bit of physics it is. Although, launching from Earth requires a large rocket like the Saturn V – as tall as the length of a football field and loaded up with nearly three million kilograms of rocket fuel – Armstrong and Aldrin launched from the moon in something about the size of a caravan with less than three thousand kilograms of rocket fuel.

With the Moon's one sixth gravity, you don't need to burn as much fuel to gain altitude – so you don't need to fly with as much fuel in the first place – so your spacecraft is lighter, which also means you don't need to burn as much fuel to gain altitude, and so on.

There is one little glitch before launch. In a supreme 'oops' moment, while moving around in the cabin, Buzz Aldrin accidently brushed against and broke off the switch that armed the ascent stage engine for lift off. There was a momentary concern this could really prevent them from firing the engine, but ingenuity prevailed and a felt-tip pen was sufficient to activate the switch.

Within twenty six minutes of launching from the Moon they were docking with Columbia. Armstrong carefully passed through 22 kilograms of moon rocks and dust – which although 'weightless', was still 22 kilograms of mass and momentum so they didn't want it careening freely about Columbia's cabin – in case, you know, it broke a switch or something.

Then it was time to jettison the lunar module ascent stage – with some sadness noted by Armstrong and Aldrin. It was set free to do a few degrading orbits until it crashed on the lunar surface somewhere – perhaps to found again by future lunar archeologists. After that, the crew spent another 5 hours in lunar orbit, stowing gear and doing systems checks – and then it was time to head home.

To recap the timeline so far, Apollo 11 had launched on the 16th of July 1969, spent 3 days getting to the Moon – had been there now for two and a half days – during which time Michael Collins and Columbia had done 30 full orbits of the Moon.

But with all of them back together now, at about 5 am on the 22nd of July – they fired up the SPS engine again for a two and a half minute burn – this being called the Trans Earth Injection manoeuvre – and they were on their way home.

The trip back was a bit quicker – only two and a half days – as Earth's gravity pulled them back. The journey was uneventful, apart from two TV broadcasts, one with the astronauts doing some tricks with food and water in microgravity – and the second one a bit more serious as they thanked all the people on the ground who had the mission possible.

Only one course correction was required on their return to Earth, a 10 second burn, which was the last time the SPS engine was used. There was no need for a retro fire as they would use the Earth's atmosphere to slow themselves down.

As they approached Earth, moving at a speed of over 11 kilometres a second, it was time to jettison the service module – which then uncovered the command module's heat shield.

The following a predetermined trajectory, the command module's heat shield came into contact with the Earth's atmosphere – becoming as hot as the surface of the Sun – and if you are a regular podcast listener you will know that it is not actually heated by friction but, like a bicycle pump, from the rapid compression of air in front of it.

With so much of its kinetic energy converted to heat energy, the spacecraft slowed down enough for a drogue parachute to be deployed followed by the three orange and white main chutes and about 15 minutes after first contacting the atmosphere, the spacecraft splashed down to the Pacific Ocean about 1,500 kilometres southwest of Hawaii at 10-to-5 pm Greenwich Mean Time on the 24th of July 1969 – 8 days and 3 hours after they first launched from Earth.

Due to concerns about possible space bugs, the Apollo 11 crew had to put on Biological Isolation Garments – essentially rubber suits and a gas mask – which were passed through the hatch of the command module. Then they were quickly transferred to a mobile quarantine facility, which was then shipped back to Houston where they transferred to the Lunar Receiving Laboratory to remain in quarantine for 3 weeks, while undergoing extensive debriefings of all steps of the mission.

Andrew Chaikin in his very readable biography *A Man on the Moon* cites that while they were in quarantine, the Apollo 11 crew were shown videotapes of the news coverage of their landing – and only then they began to appreciate the awe that everyone else back on Earth had felt when they stepped out on to the Moon. Allegedly, Aldrin turned to Armstrong and said "Neil, we missed the whole thing."

Amongst the minerals in the moon rocks they brought back was a titanium rich, sodium poor, basalt not previously identified on Earth. It was decided to call this new mineral Armalcolite – after Armstrong, Aldrin and Collins.
Armalcolite is a common mineral in the greyish maria of the Moon, like the Sea of Tranquility, which are really just ancient lava up-wellings following a large asteroid or comet impact early on in the Moon's formation.

Oh – and nicely timed for the 40th anniversary of the first Moon landing – NASA has just released images taken by the new Lunar Reconnaissance Orbiter showing nearly all the Apollo landing sites – and the Eagle's descent stage is clearly visible. But hey, it's probably faked.

Many thanks for listening. This is Steve Nerlich from Cheap Astronomy, www.cheapastro.com. Cheap Astronomy offers an educational website where space exploration doesn't have to cost the Earth. No ads, no profit, just good science. Bye.

Lunar Module launch (Apollo 17):
http://www.youtube.com/watch?v=Obd_jTO66-0
LRO images:
http://www.nasa.gov/mission_pages/LRO/multimedia/lroimages/apollosites.html