Apollo Moon Landings

A Resource for Understanding the Hoax Claims

A Millennium Commission Lottery Project

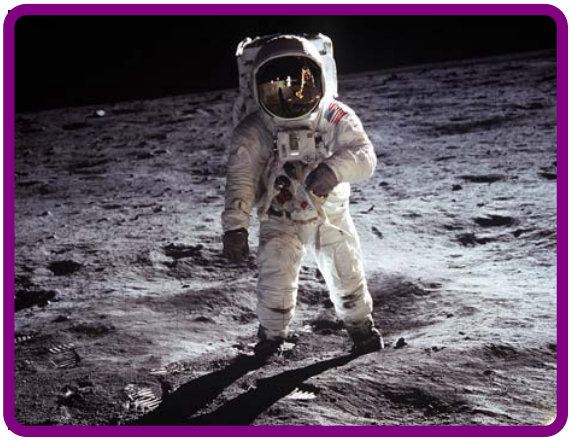
National Space Centre

Introduction

This document is intended as a resource for teachers and members of the public who would like to understand more about recent claims that the Apollo Moon landings were a hoax.

On 16 July 1969, Apollo 11 blasted off from Kennedy Space Centre's launch pad 39A. Propelled into space by the giant Saturn V rocket, Neil Armstrong, Michael Collins and Edwin (Buzz) Aldrin, began their historic journey to the Moon. Four days later, on 20 July 1969, Armstrong and Aldrin landed the Lunar Module (The Eagle) on the surface of the Moon, at the Sea of Tranquillity (0°4'5"N, 23°42'28"E).

At 2:56:15pm (GMT), Armstrong stepped out of the Lunar Module and into the history books with the words, "That's one small step for man, one giant leap for mankind". From that point on, we have lived in a world where man has walked on the Moon! As Albert Szent-Gyorgyi so eloquently puts it, "The Apollo flights demand that the word 'impossible' be struck from the scientific dictionary. They are the greatest encouragement for the human spirit."



Edwin (Buzz) Aldrin on the surface of the Moon during the historic Apollo 11 mission

After 21 hours 38 minutes and 21 seconds on the lunar surface, the two astronauts launched the ascent stage of the Lunar Module and rejoined Command Module pilot, Michael Collins on board Columbia, and they headed back to Earth. The module splashed down in the Pacific Ocean on 24 July and awaited recovery by the USS Hornet.

Another 5 successful lunar landings followed between 1969 and 1972, with the failed mission of Apollo 13 telling its own story of human courage and determination. When the 25 billion dollar Apollo Program was finally concluded, 12 men had walked on the face of another world, and had stretched the frontiers of possibility for future generations.

Over 30 years have past since those pioneering missions, and in that time a small number of critics have persistently claimed that the Moon landings did not take place. These ideas have been presented to a wide audience in recent years through television and the Internet. As a result, seeds of doubt have been sown, and it is now not uncommon for children to ask their teachers if the Moon landings really *did* happen. There are a number of resources available on the Internet that present a case against the conspiracy theories. This document is offered as an additional resource, with the hope that it may play some small part in restoring confidence in the historical fact of the Moon landings.

Whilst not comprehensive, the following pages deal with the main issues raised by those who question the authenticity of the Apollo Lunar landings.

STARS

Why are there no stars in the background of the Apollo pictures, even though the sky must be totally clear and dark due to the lack of atmosphere on the Moon?

Like many of the claims we will look at in this document, the idea that there should be lots of stars in the Apollo pictures seems very logical on first consideration. If we go out on a clear night and look up, we see many stars, even from light polluted towns and cities, so why would the Apollo astronauts not also see even more stars?

Even if they could have seen the stars (the bright light from the lunar surface would actually have stopped their eyes becoming dark adapted) the issue is not what they saw with their eyes, but what the film in their cameras picked up. Those who have tried capturing stars on film know that it can be quite a challenge. Stars are very faint, so to gather enough light from them to stimulate the necessary photochemical reactions on the film, a long exposure time of several seconds is needed.

Buzz Aldrin, training with the chest-mounted Hasselblad camera before the Apollo 11 mission

However, the Apollo astronauts were not trying to take pictures of stars! If they had used exposure times appropriate for star images, the real subject of their photographs (the lunar surface and their presence there) would have become blurred, overexposed smudges.

A good comparison is to look at other images taken in space, such as those of the International Space Station, the Hubble Space Telescope, MIR, or the Space Shuttle. Again, none of these images show any stars in the background, because they were not the subject matter of the photos.

Notice the lack of stars in this image of Hubble Space Telescope captured by the STS-109 astronauts on 3 March 2002

A revealing experiment can be carried out using very basic equipment. Simply take a digital or traditional camera outside on a clear night and attempt to take a picture of the stars with a standard exposure time (say 1/250 second). Obviously a digital camera will give the quickest results, but either will produce a blank picture with no stars.

Dust

The Lunar Module's main engine delivered 4,500 kilograms of thrust, so why is there no dust on the footpads of the LM, or blast crater in the dust under the LM?

Again, it would seem reasonable to expect dust to have settled on the footpads of the Lunar Module (LM) after it landed, and maybe to see a crater carved out by the pressure from the main engine. Unfortunately, what may be a reasonable expectation on Earth does not always hold true for the Moon.

A footpad of an Apollo Lunar Module with no signs of dust on top

This idea, like a number of the hoax claims, is built upon a fundamental misunderstanding of the bizarre lunar environment.

With the Moon's gravity being just 1/6th of the Earth's, one might expect the dust to fall more slowly. However, the Moon has no atmosphere to speak of, so the dust was actually in a vacuum. With no air to float on, dust on the surface of the Moon would actually fall more quickly than on Earth. Another consequence is that the dust would not spread out in billowing clouds, as this is again a phenomenon restricted to planets with atmospheres.

With regard to the absence of a blast crater, there are a couple of points to make. Firstly, the 4,500 kilograms of thrust were spread across the area of the engine nozzle, which was around 15,000 cm^2. This is equivalent to just 0.3 kilograms/cm^2.

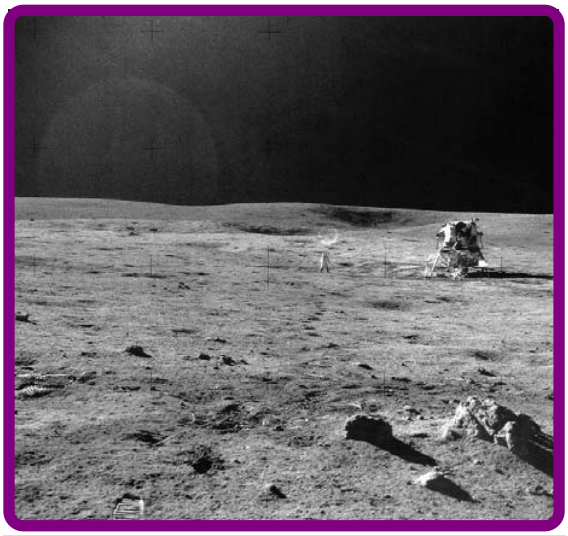
Secondly, the engine would not have been firing on full thrust when the astronauts were coming in to land. As no exact landing site was known, the Lunar Module was actually flown in at an angle, thus allowing the pilot to see out of the LM's window to select the best available terrain to land on. The result of all this was a rather gentle thrust from the engine once the LM was finally straightened up and landed. The only dust disturbed was that which was in direct contact with the LM's exhaust. This dust fell quickly to the ground in the direction it was pushed - away from the immediate landing site.

An interesting example of the strange behaviour of dust in the low gravity, vacuum environment of the lunar surface is supplied by Apollo 16 video footage. When astronaut Charles Duke drove the Lunar Rover at speed on the Moon's surface, the dust flew up and back down in a perfect arc, described by fellow astronaut John Young as a rooster tail. Had these images been filmed on Earth, a cloud of dust would have been produced, which would have dispersed in the atmosphere.

Shadows & Lighting

The shadows of the astronauts and their equipment appear to point in different directions, why is this so if the Sun is the only light source?

There are two main points those who promote the hoax claims raise about the shadows in the Apollo images. Firstly, the shadows in the pictures seem to point in different directions. Secondly, the astronauts seem well lit at times when they should be in shadow. Both these arguments suggest that artificial lighting was used and therefore the pictures were taken in a studio on Earth.



Shadow from the Lunar Module in the distance appears to point in a different direction to those from the rocks in the foreground

The directions and lengths of shadows are determined by a combination of the slop of the ground and differences in the depth of field of objects in the photographs. Just as parallel train lines, when represented in a 2D image, appear to meet a vanishing point in the distance, so shadows of objects at different distances will appear to radiate from a common point. Such variations in shadow length and apparent direction are common in many photographs taken on Earth.

Shadows in a photograph on Earth showing the same alignment as those in the Apollo images

When considering well-lit astronauts in shadow, it is important to realise that direct sunlight was not the only source of light available. Reflected light from the lunar surface would easily provide enough light to illuminate an astronaut in a white spacesuit. This would work in a similar way to the reflectors used by portrait photographers to fill in shaded areas.

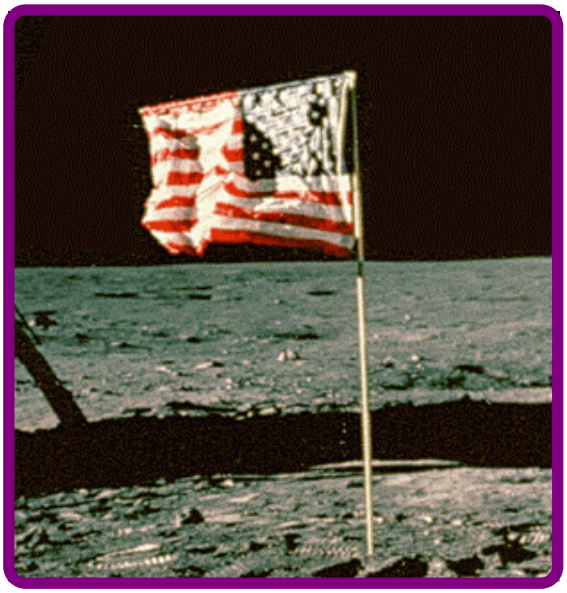
Buzz Aldrin descends the ladder of the Lunar Module in the shade of the craft

Flags & Radiation

Why does the American flag, planted by the Apollo astronauts, appear to flutter when there is no atmosphere on the Moon?

How would the astronauts survive the radiation in the Van Allen Belt?

The American flag is seen moving in video footage recorded when the astronauts planted it on the lunar surface. Given that there is no atmosphere on the Moon, some see this as 'proof' that the scenes were filmed on Earth.

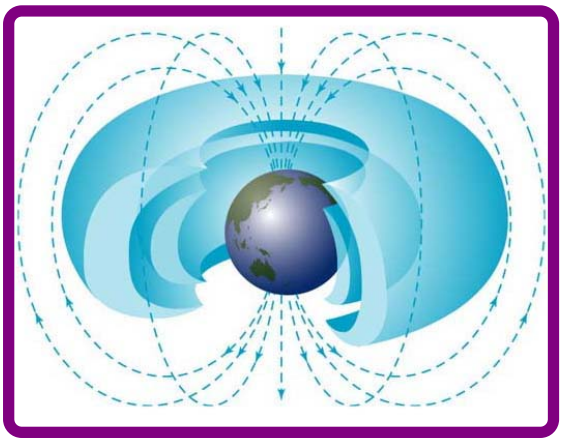


The American flag planted by the Apollo 11 astronauts on the first lunar landing

The flag only actually moves when, or just after, the astronauts have touched it. This suggests that the movement is the result of vibrations travelling through the solid pole and disturbing the flag. With no atmosphere to dampen the movement of the flag, and only 1/6th of the gravity of Earth pulling it downward, it is not surprising that the material would move for longer, and in ways that would not be expected on Earth.

Once again, it is the Moon's strange environment that causes things to act in ways that do not fit with our everyday experiences on Earth.

The Van Allen Belt is a band of concentrated radiation around the Earth. Some who hold to the conspiracy theories have suggested that the Apollo astronauts could not have survived the journey through the belt, so they cannot, therefore, have been to the Moon.



A graphical representation of the Van Allen Belt

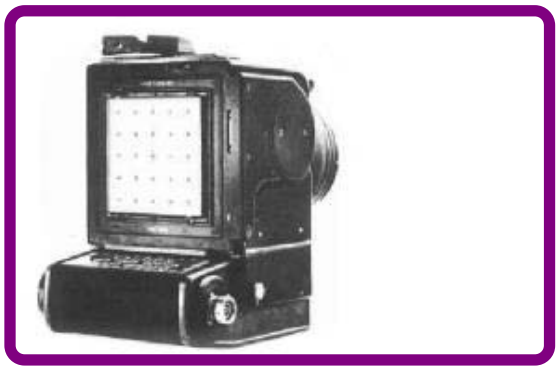
However, the Saturn V rocket that took the astronauts to the Moon propelled them at tremendous velocity. If we work from a conservative average velocity of 25,000 km per hour (allowing for a reduction in velocity once the main engines had finished burning) the time taken to pass through the Van Allen Belt would have been around 1.5 hours. This equates to an exposure of between 1 and 2 rem. Radiation sickness symptoms do not start to show until around 25 rem.

While it is not possible to say that an astronaut travelling through the Van Allen Belt will never experience any ill effects, it is reasonable to assert that they would not experience any immediate health problems that would prevent the journey.

Photographs

The crosshairs on the lunar surface pictures sometimes disappear behind an object, so have they been added after the images were taken, providing evidence of tampering?

Lunar surface cameras were fitted with a device called a reseau plate. The plates were etched with small black crosshairs. These plates pressed against the film so that any image exposed on the film would contain a grid of these marks, called "fiducials".

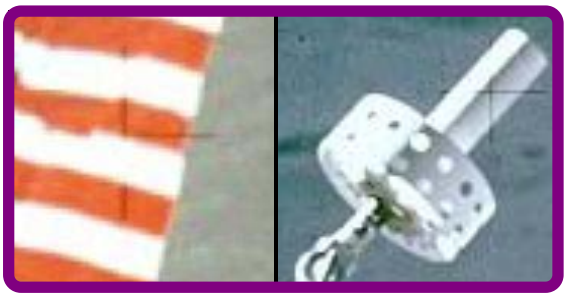


A Hasselblad camera with the film magazine removed to reveal the reseau plate

In some Apollo images the crosshairs appear to disappear behind an object. Some see this as evidence that the crosshairs have been added afterwards. In reality, the film emulsion has become saturated with light from a bright object and it has bled into the area covered by the crosshair.

A crosshair (fiducial) appears to disappear behind the object in this photograph

This explanation is born out by other images that show parts of the crosshairs missing only on bright areas within a single object.



These Apollo images show the results of bleeding on bright areas within individual objects

Others have noted that crosshairs do not always appear level on the photographs. It is important to note that the camera was not mounted on a tripod, but attached to the astronaut's chest. As a result, one would expect some images to be slightly off horizontal. The images would go through processing that might include being realigned and cropped before being released.

There are numerous claims relating to the quality of the images. Some say they are all too good, but no doubt it is only the good ones that have been circulated. Others say the TV images are too poor, as if NASA didn't want people to see detail. Apart from revealing how unreasonable these arguments can be, it is not surprising that the equipment available at the end of the 60s, transmitting from 384,000 kilometres away, did not result in high quality images.

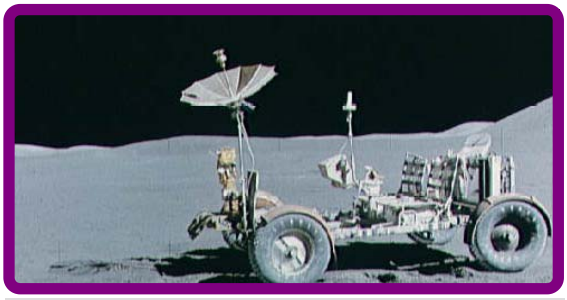
Equipment

How could the equipment that is shown in the Apollo images have been transported to the Moon, and have functioned in such hostile conditions?

The mean surface temperature on the Moon ranges between 107°C in the daytime Sun (the lunar 'day' last around two weeks!), down to -153°C during the lunar nighttime. Given these extremes, it may seem obvious that the film used in the cameras would melt, so we should not have any images at all!

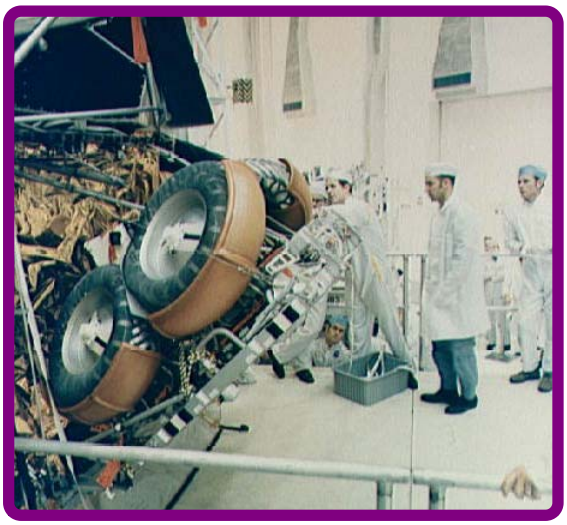
What we need to understand is what is meant by 'surface' temperature. Most of us can remember walking barefoot across a beach on a hot summer's day and finding the heat on the soles of our feet almost unbearable. Yet the air around us would have been only *warm* by comparison.

This is because heat is transferred by different methods; radiant transfer from the Sun's rays heats the sand, conductive transfer heats the soles of our feet, and convective transfer heats the air above the sand. Now, if we shift our scene to the surface of the Moon, where there is no atmosphere, we can see that convective heat transfer would not be possible. The only heat transfer the film would experience is either radiant or conductive. With the film inside a camera, which was not in direct sunlight for several days like the lunar rocks and dust, it would have stayed within its working temperature range.



The Apollo 15 Lunar Roving Vehicle (LRV) on the surface of the Moon

An objection that is often raised by the conspiracy theorists is the size of the Lunar Roving Vehicle. The vehicle was 3.1 metres long by 2.3 metres wide, and 1.14 metres high. As the Lunar Module's descent stage was only 4.3 metres in diameter by 3.2 metres high, one might think this would not have left much room for the remaining equipment. However, the LRV was designed to fold up and fit into a wedge-shaped stowage compartment to the right of the ladder on the descent stage of the Lunar Module.



The Lunar Roving Vehicle folded and ready to be inserted into its wedge-shaped stowage compartment

The tyres of the LRV have also been brought into question, as many think they would be likely to explode in the vacuum of space. Again, a simple bit of homework reveals that the tyres were not of the traditional inflated, rubber variety. The purpose built LRV tyres were actually made from a mesh of zinc-coated piano wire, to which titanium treads were riveted in a chevron pattern.

Proof?

What evidence is there that the Apollo Moon landings actually took place?

Rocks, Telescopes, and Occam's Razor!

There are many reasons to believe the Apollo Moon landings took place, not least of all because it is quite possibly the most thoroughly documented event in history. To pick just one of the many lines of evidence confirming that the Moon landings really happened, we turn to the 382 kilograms of lunar material that have been return to Earth by the 6 Apollo missions, and consequently studied by many scientists from around the world, including the Soviet Academy of Sciences.

View of Apollo 17 lunar rock sample no. 76055

The samples of rock appear similar to terrestrial rocks on the surface, but chemically and structurally they are unlike anything on Earth. This is to be expected, since they formed in a markedly different environment.

To start, the surface of lunar material is covered in 'zap pits', microscopic evidence of bombardment by micrometeorites on the lunar surface. Such micrometeorites burn up in the Earth's atmosphere, but the Moon offers no such protection. Also, the minerals are said to be 'anhydrous', i.e. they contain no water or signs of water being involved in their formation. Coupled with evidence of long-term interaction with the Solar Wind, the experts agree, these rocks came from the Moon.

So, why doesn't NASA just point the Hubble Space Telescope at the Moon and show us pictures of the equipment they left behind? Firstly, it is unlikely that any photographic evidence that NASA produced would convince die-hard conspiracy theorists. More importantly, it just wouldn't work. Even the largest pieces of equipment left behind by the Apollo missions are far to small to be seen by even the most powerful telescope.

Images from Hubble are captured digitally, in the same way as the pictures you might take with a digital camera. If you zoom in on a digital image, you will notice that it is made up of lots of squares, called 'pixels' (picture elements). The Lunar Module would need to be around 15 times bigger than it actually is to fill just one of these pixels on a Hubble Image.

Even probes in orbit around Mars return images with resolutions measured in metres per pixel, which means only objects the size of a jumbo jet would be discernable in such pictures.

In concluding, it is helpful to apply a scientific principle known as Occam's Razor, after William of Occam, a 14th Century thinker. He suggested that when there are two or more explanations for an observation, the least complicated explanation is to be favoured.

Given that over 400,000 people were involved in the Apollo Program, and we have already suggested it is the best-documented event in history, the least complicated explanation is surely that we live in a world where man has indeed walked on the Moon.

Acknowledgements

There are many great resources on the Internet that have been consulted in preparing this document. If you have found this helpful in explaining the hoax claims, we hope you will take some time to visit these sites and look into this subject in greater depth.

Images

The pictures used in this document are provided courtesy of NASA

Websites

Moon Base Clavius ~ http://www.clavius.org/index.html

Bad Astronomy ~ http://www.badastronomy.com/bad/tv/foxapollo.html

Moon Hoax ~ http://www.redzero.demon.co.uk/moonhoax/

Apollo Hoax ~ http://www.apollo-hoax.co.uk/homepage.html

Did we Land on the Moon? ~ http://www.bestofcolumbus.com/braeunig/space/hoax.htm

Kennedy Space Centre Library ~ http://www-lib.ksc.nasa.gov/lib/PressKits.html

Moon Rock Samples (USA) ~ http://curator.jsc.nasa.gov/curator/lunar/lunar.htm

PPARC's Lunar Sample Loan Scheme (UK) ~ http://www.pparc.ac.uk/Ed/LS/moon.asp

National Space Centre ~ http://www.spacecentre.co.uk

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The National Space Centre was co-founded by The University of Leicester and Leicester City Council and is the Millennium Landmark Project for the East Midlands. Its other founding partners are BT and East Midlands Development Agency.

For other resources or to book a visit contact National Space Centre, Exploration Drive, Leicester LE4 5NS UK, +44(0) 116 261 0261, or visit www.spacecentre.co.uk

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