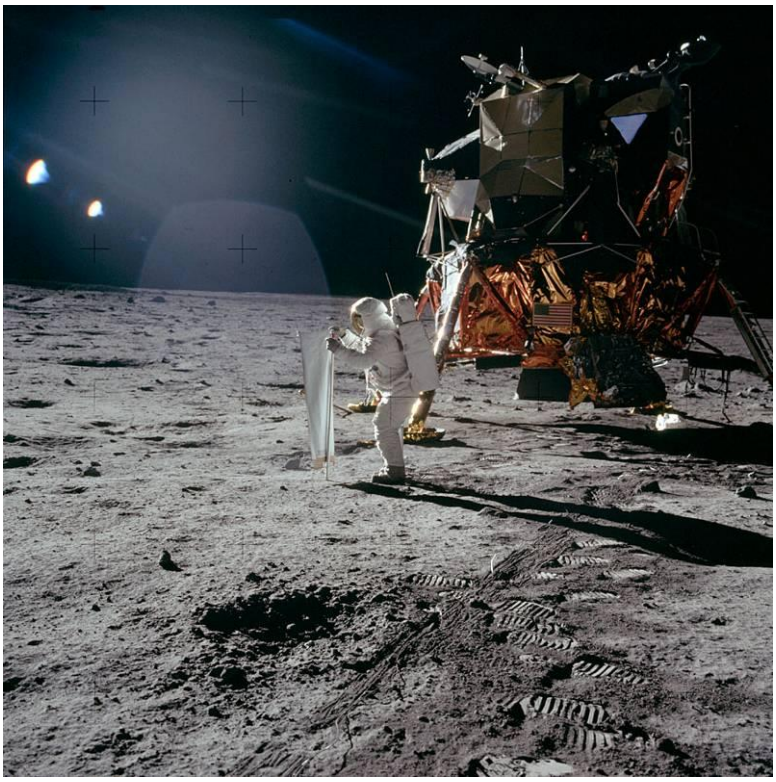
Scenery of the NASA-Pictures of the Moon Landing of Apollo 11

1. Motivation and Introduction

The motivation for this analysis was a recently published picture where Aldrin is deploying the solar wind collector. Among others the near and flat horizon raised the question whether this picture was really taken on the Moon or in an artificially illuminated scenery on the Earth. This question is closer investigated here. Further pictures of the same NASA scene and the live Moon landing video are addressed to elaborate the shape of the landing area and to estimate its authenticity.



This is the picture of the NASA homepage:
http://www.history.nasa.gov/alsj/a11/images11.html - Mag40
It is the picture AS-11-40-5872.jpg
Link directly to the picture:
http://www.history.nasa.gov/alsj/a11/AS11-40-5872.jpg

Picture 1 „Buzz is deploying the Solar Wind Collector“

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2. Visibility range

For the following investigations the visibility range on the Moon on a flat and horizontal area is used. This can easily be calculated (see appendix 1) and is for a (camera) height of 1.50 m

- on the Moon 2.3 km and for comparison
- on the Earth 4.4 km.

1.5 m is assumed as a medium camera height in the following. Smaller deviations are not relevant because of the low dependence: for a camera height of 1 m the visibility range on the Moon is still 1.9 km.

On Picture 1 the distance to the border is estimated to 50-100m. The camera is more than 1.5 m over the ground because one can almost see over Aldrin.

The following pictures show the characteristics of the horizon in other directions.

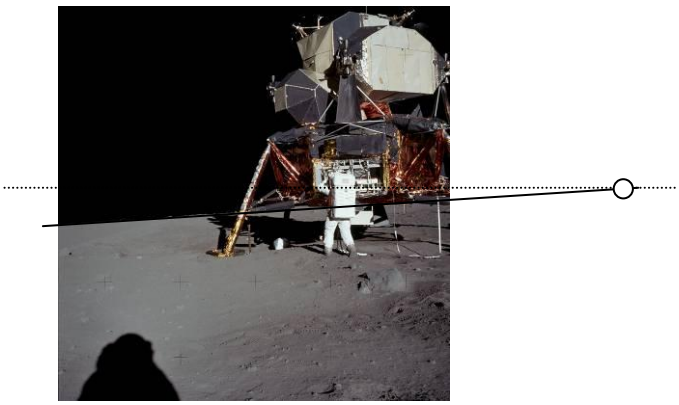
AS11-40-5928.jpg

AS11-40-5931.jpg

AS11-40-5868.jpg

Picture 2 Characteristics of the Horizon Middle left – middle – and right

On the left two pictures above the short visibility range looks obvious: one can just see up to the end of the shadow of the LM (Lunar Module), and this is independent of the position of the observation.
Because the visibility on the Moon in a plane area is 2.3 km (at a camera height of 1.5 m), the observer is not looking tangentially in a wide plane, but only up to the border of the illuminated scenery.



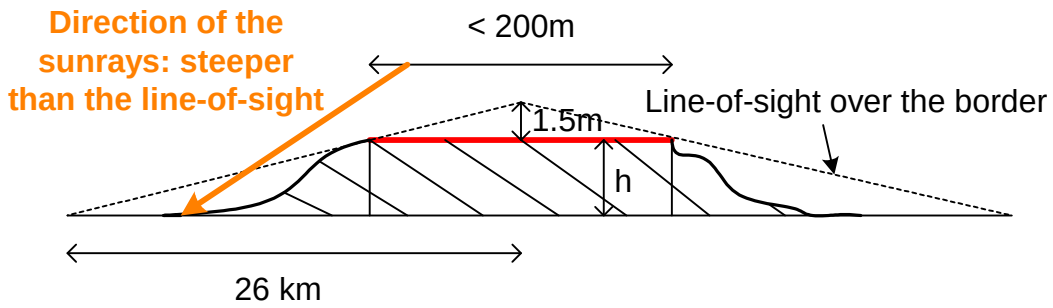
AS11-40-5928.jpg

AS11-40-5868.jpg

Picture 3 As Picture 2, but with horizon line, vanishing line and vanishing point (see § 4)

3. Scenery

A natural scenery which fulfils the visibility of the above pictures is an elevated plain of approximately the size and form of a football ground. Within the investigated pictures there are none in the direction of the Sun, so the dimension in this direction can not be estimated (a picture in the direction of the Sun can be found under http://www.apolloarchive.com/apollo_gallery.html, picture AS11-40-5863-69). Behind the horizon nothing is visible. There are no larger hills. A natural scene would have to look as follows:



Picture 4 **Vertical section through a landscape (red), where only the plateau is visible (not to scale and exaggerated in height)**

Behind the visible horizon line the area must be inclined. The sharp limitation gives the impression of a ridge.
The height h above the sea level, i.e. the ground of the Sea of Tranquility where Apollo 11 landed, can be estimated as follows: assuming again a camera height of 1.5m and a distance to the ridge border of 100m, then the sight angle is 0.86° below horizontal (see appendix 1). Since no further ground is visible, the plateau is at least 196m (h) above the "sea level", and there are – as shown in the drawing – no hills in the next 26km (appendix 1) which exceed the line-of-sight.
Since the Sun is shining significantly steeper than the line-of-sight to the border, the landscape behind the border would be illuminated. The steeper Sun illumination can best be seen in the left picture of Picture 2: the shadow of the astronaut who made the picture would go up to the border if the Sun illumination had the same steepness as the line-of-sight to the border.

Many pictures were made almost perpendicularly to the border lines, so that the horizon is only a bit too low, what is hardly striking out on a single picture (Picture 1 and Picture 2 middle). On the pictures made obliquely to the border line the perspective of these border lines is correct (Picture 2 left and right). Looking at a single picture one imagines an acclivity (Picture 2 right). But the scene is flat as one can see on the following picture:

as11-5864-69.jpg (http://www.history.nasa.gov/alsj/a11/as11-5864-69.jpg)

Picture 5 **Slightly different perspective than Picture 2 right**

4. Comparison with the Moon Landing Video

During the landing of Apollo 11 a first TV black and white video has been broadcasted. This video can be found e.g. on the homepage of the Swiss TV (see Archiv: http://www.sf.tv/archiv/schonvergessen.php?month=07) or directly on the NASA-homepage http://www.hq.nasa.gov/alsj/a11/video11.html#Step, at 109:42:28).

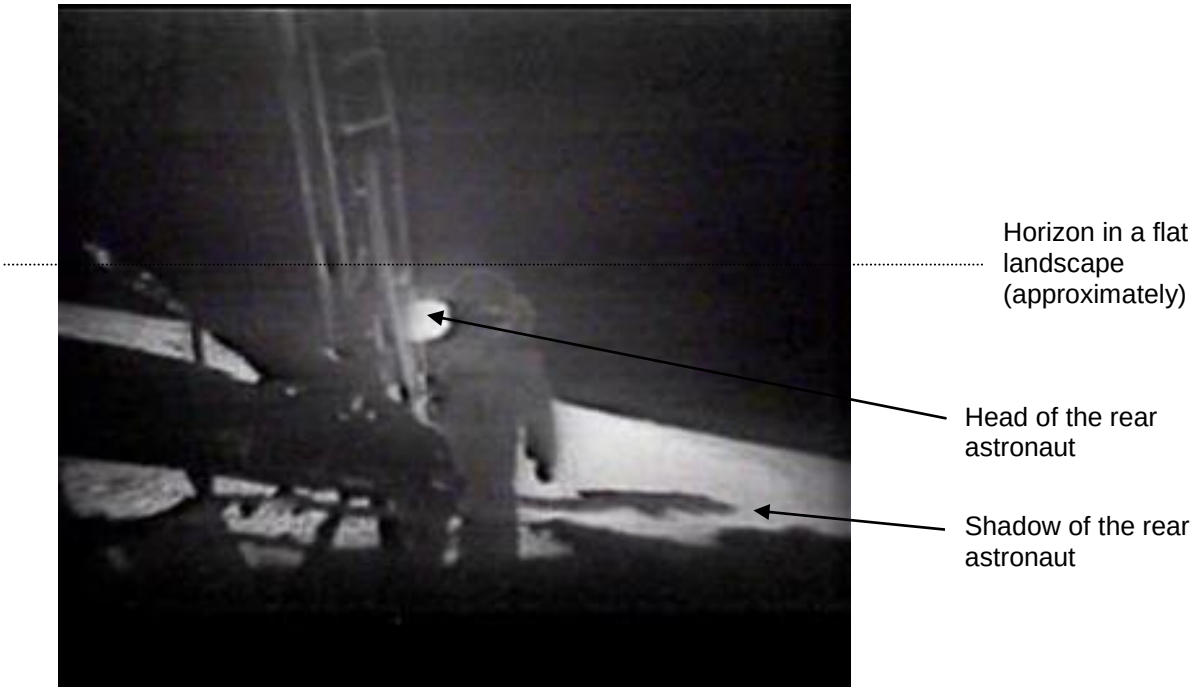
Picture 6 Scene from the Moon Landing Video

Visibility range and horizon correspond with the two pictures on the left in Picture 2. Also here one can see only up to the border. The distance to the closest point of the border of the scenery is maximum 30m and the camera is higher than 1.5 m because one looks down to the astronaut. Under such a sight angle[1] one would view from 2000m altitude over a distance of 87km into a plain country of the Moon. But since nothing is visible behind the border, one would have to stay on a mountain which is higher than 2000m (7'000 feet). If the plateau were below 2000m, one could see in the background the ground of the Sea of Tranquility. The oblique horizon shows a same ridge border as in Picture 2. The straight and flat border is heading for the vanishing point, as it results at such perspectives.

Also in the Pictures 1 and 2 (left and right picture) one can easily determine the vanishing point by drawing the horizon line on the height of the camera and by extending the border line.
For Picture 2 this has been made in Picture 3. In appendix 2 the characteristics of the horizon are demonstrated with re-enacted scenes with similar view angles.

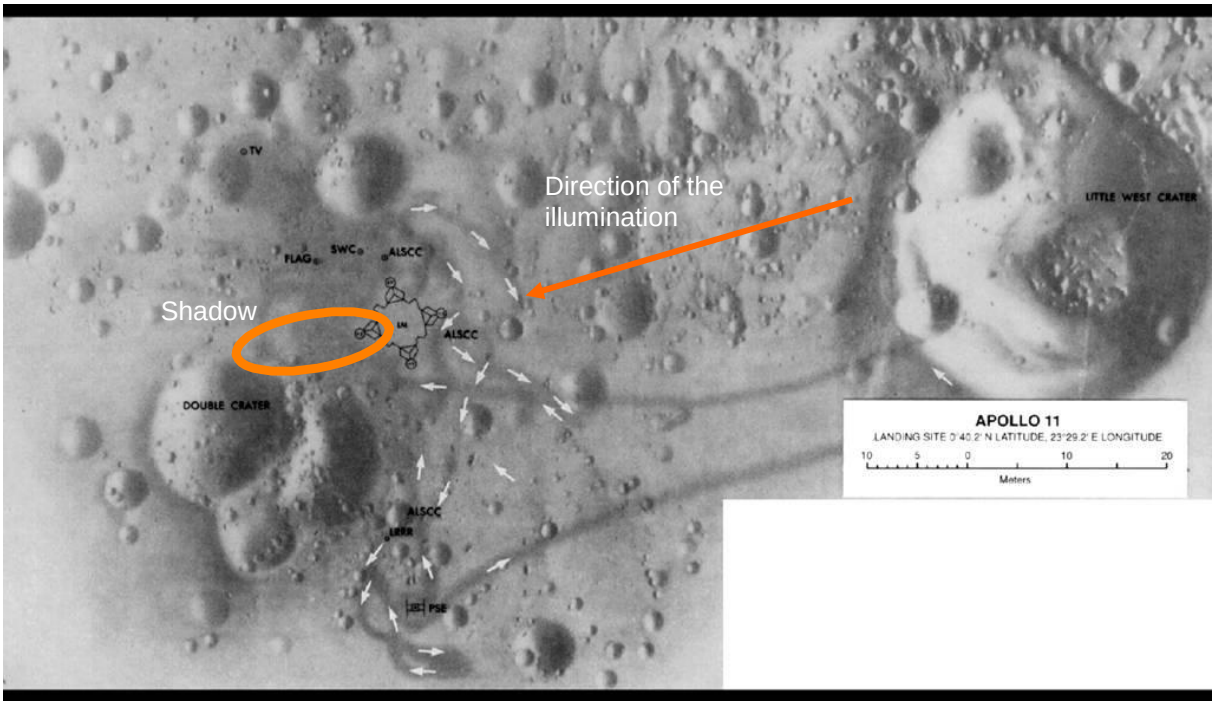
[1] At a height of 1.5m and a distance of 30m there results a view angle relative to the horizon of 2.86°, and from this an altitude h of 2171m and a visibility range d of 87km (appendix 1).

Picture 7 confirms once again the result of the previous chapter, to wit that the Sun is shining steep enough to illuminate distant parts of the Moon behind the ridge border. The Sun is also here shining steeper than the line-of-sight from the camera to the closest point of the border, what can best be seen on the shadow of the rear astronaut. With other words one should see in the background further lunar landscape, except one would stay on a 2000m (7000 feet) high ridge – as described before.
If the scenery were level, the horizon would be on the height of the camera; if there were mountains or hills, then the horizon would be higher.



Picture 7 Scene of the Moon Landing Video showing the Shadow of the rear Astronaut

On the map of the following picture the scene is shown as a plain with craters; there is no indication of a ridge or a ridge border. The map can be found on the NASA homepage (http://history.nasa.gov/alsj/a11/a11_lpi_trvrsmap.gif).



Picture 8 **Map of the landing site. The direction of the illumination is approximately indicated as well as the shadow of the LM.**

For the sake of completeness there is added Picture 9 showing the flag. Because the flag is on the right of the shadow, looking from the LM, and because the shadow covers one strut (the one with the ladder), the Sun must shine from the right on the map. I have both indicated on the map in Picture 8 in orange. The length of the shadow is approximately calculated according to Picture 1 as follows:
The shadow of the solar wind collector is on the picture about 2.6 times longer than its height (in reality it is even a bit longer, because the shadow is perspectively shortened on the picture; but this is neglected). With an approximate height of the LM of 6.5 m (according to Wikipedia: „Apollo Lunar Module“: 6.37m)[2] a length of the shadow of 2.6·6.5m ≈ 17m results.

AS11-40-5875

Picture 9 **Position of the flag in the plain landing site**

[2] According to http://www.hq.nasa.gov/alsj/LM04_Lunar_Module_ppLV1-17.pdf the height is 7.0m.

5. Summary and Conclusion

The landing site is limited by horizontal straight lines or borders and there is no background. A lunar landscape onto which such pictures could be taken ought to have the shape of a soccer pitch and to be elevated by more than 2000m (7000 feet) above the surrounding surface of the Moon. This is in a huge contradiction to the landing area, the plain Sea of Tranquility and to the shown map of the landing site.
From all this I can only conclude that these pictures were taken on the Earth on a limited and illuminated area – most probably in a studio. The straight borders could have been achieved by the illumination combined with the shape and adjacent materials, similar to the official studio pictures. The background of these pictures was probably reworked.

http://history.nasa.gov/alsj/a11/ap11-S69-32247.jpg
(Slightly truncated)

Picture 10 Official studio picture (training)

I can not explain the missing background with other effects, e.g. with an inclined site or a site which has a shape of a plate or a crater, so that one could not see above the border. The quality of the pictures is too good and the distances are too short. The shortest distance to the border can be seen on the Pictures 6 and 7.
Also the possibility that these pictures were really taken on the Moon and that the background was cut away does not seem to be a real option for me.

Revised, July 2010: see Homepage

Personal appraisal and benefit:

~~It seems unlikely to me that the Moon landing was pretended only with these studio pictures and that all confidants kept this secret. I therefore assume that the Moon landing took place on the 20th of July 1969.~~

With these pictures and the “live” broadcast, which had been available already before the expedition, the Moon landing got a perfect media event. Everybody has it in best remembrance and due to the high quality of the pictures also in a colourful one.

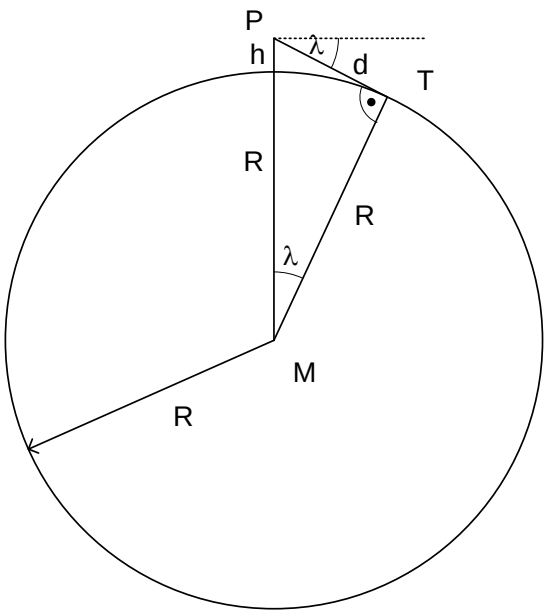
~~The discussion can be more open now and there are other questions to ask, e.g.: did the astronauts hardly make any pictures to be able to focus on the experiments – or wouldn’t they have been in the position to make so many high quality pictures in the short time?~~

With the knowledge that all these are studio pictures, all detail discussions about unnatural illumination, the waving flag, missing traces from the rocket engine and other possible inconsistencies are now superfluous and clarified in all.

~~All the same I would like to see once also a real picture of the Moon landing site of Apollo 11.~~

Appendix 1: Calculation of the Visibility Distance (d)

R: Radius of the Earth: 6370 km Radius of the Moon: 1738 km



Picture 11 Calculation of the horizontal visibility distance on a sphere

Visibility distance from the height h
(from the observer P to T, the most distant visible point on the sphere):

$$R^2 + d^2 = (R+h)^2$$

$$\Rightarrow d = \sqrt{2 \cdot R \cdot h + h^2} \approx \sqrt{2 \cdot R \cdot h}$$

Example Earth, h=1.5m: $d \approx \sqrt{2 \cdot 6370km \cdot 0.0015km} \approx 4.4km$

Example Moon, h=1.5m: $d \approx \sqrt{2 \cdot 1738km \cdot 0.0015km} \approx 2.3km$

Visibility distance for an unknown height h, but a given angle λ (to the horizontal):

1. Calculation of h:

$$R + h = \frac{R}{\cos(\lambda)}$$

$$\Rightarrow h = \frac{R}{\cos(\lambda)} - R = R \cdot (\frac{1}{\cos(\lambda)} - 1)$$

2. Insertion in the above formula:

$$d \approx \sqrt{2 \cdot R \cdot R \cdot (\frac{1}{\cos(\lambda)} - 1)} = R \cdot \sqrt{2 \cdot (\frac{1}{\cos(\lambda)} - 1)}$$

Example Moon, with $\lambda = arctg(\frac{1.5m}{100m}) = 0.86° = 15mrad$:

$$\Rightarrow h = 196m; \quad d \approx 26km$$

(or direct calculation of the arc: λ·R = 0.015rad·1738km = 26km)

Appendix 2: Pictures for the Clarification of the Horizon Characteristic

The situation was re-enacted on the sports ground shown below to demonstrate the course of the horizon if only the rectangular turf were illuminated and were visible – and beyond the turf nothing were visible and everything were black. But the real landscape continues also behind the border of the turf and does not end abruptly.
The re-enacted pictures were made with similar perspectives as the NASA pictures so that the horizon or border lines have similar directions. However the distances are different compared to the “Moon pictures”, in particular the ladder is much smaller than the LM.

The re-enacted pictures are always shown in pairs: first the original picture, then the same picture again with the background behind the turf rudimentarily black painted, to highlight the similarity of the perspective and to demonstrate how it would look if one could only see up to the border of the turf.

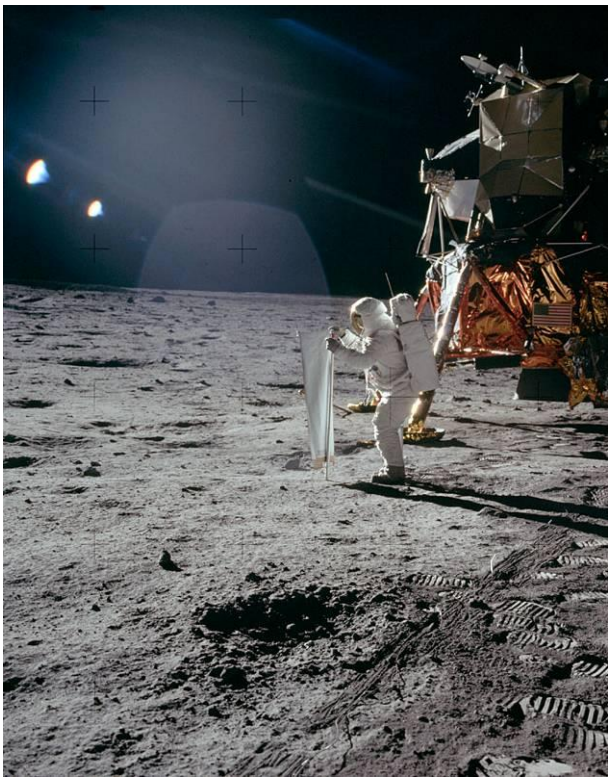
Picture 12 Sports ground where the following pictures were made

Picture 13 Scene according to Picture 2 left

This picture shows the background landscape, which is hardly visible on the right due to haze.

Picture 14 Scene according to Picture 2 right

Picture 15 Scene according to Picture 6



Picture 16 Scene according to Picture 1