How can the NASA Lunar Mapping and Modelling Project be used to find a suitable landing site for Lunar Mission One?

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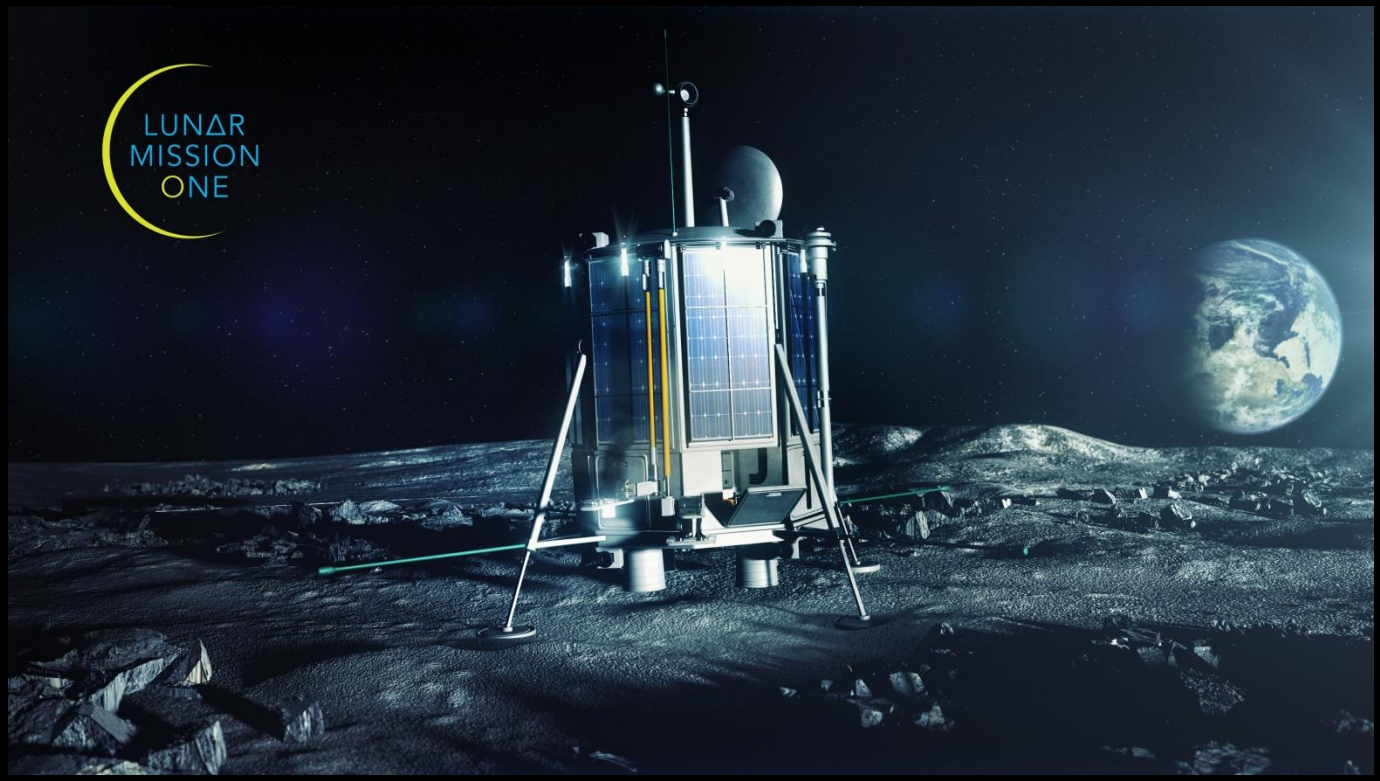
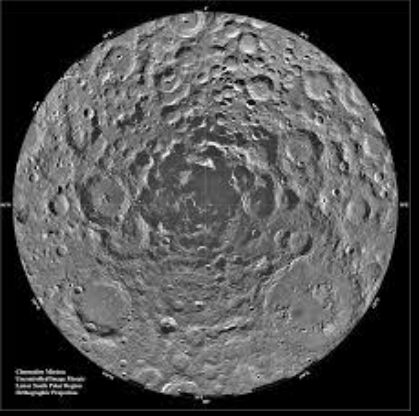


Outline

1. Introduction and overview to Lunar Mission One
2. Methods for landing on the Moon
3. Site selection criteria and the LMMP
4. Crowd sourcing solutions
5. Educational applications of this project



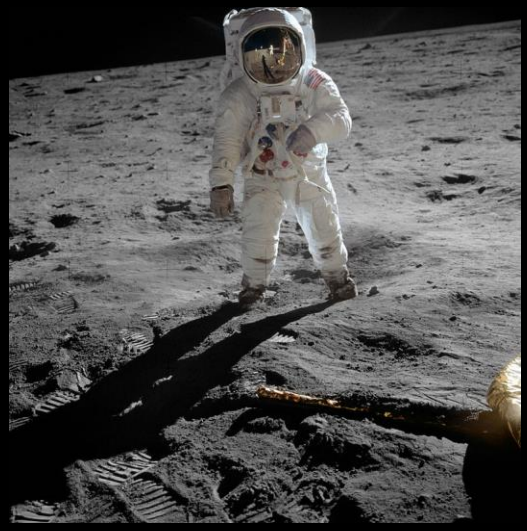
Lunar Mission One Project Overview

- A crowd funded project aiming to drill a bore hole between 20-100m deep on the South Pole of the Moon in order to
  - Analyse rock samples
  - Place an archive in the bore hole
- The mission is funded through paying members of the public creating private archives themselves (including their own hair).

Mission Area

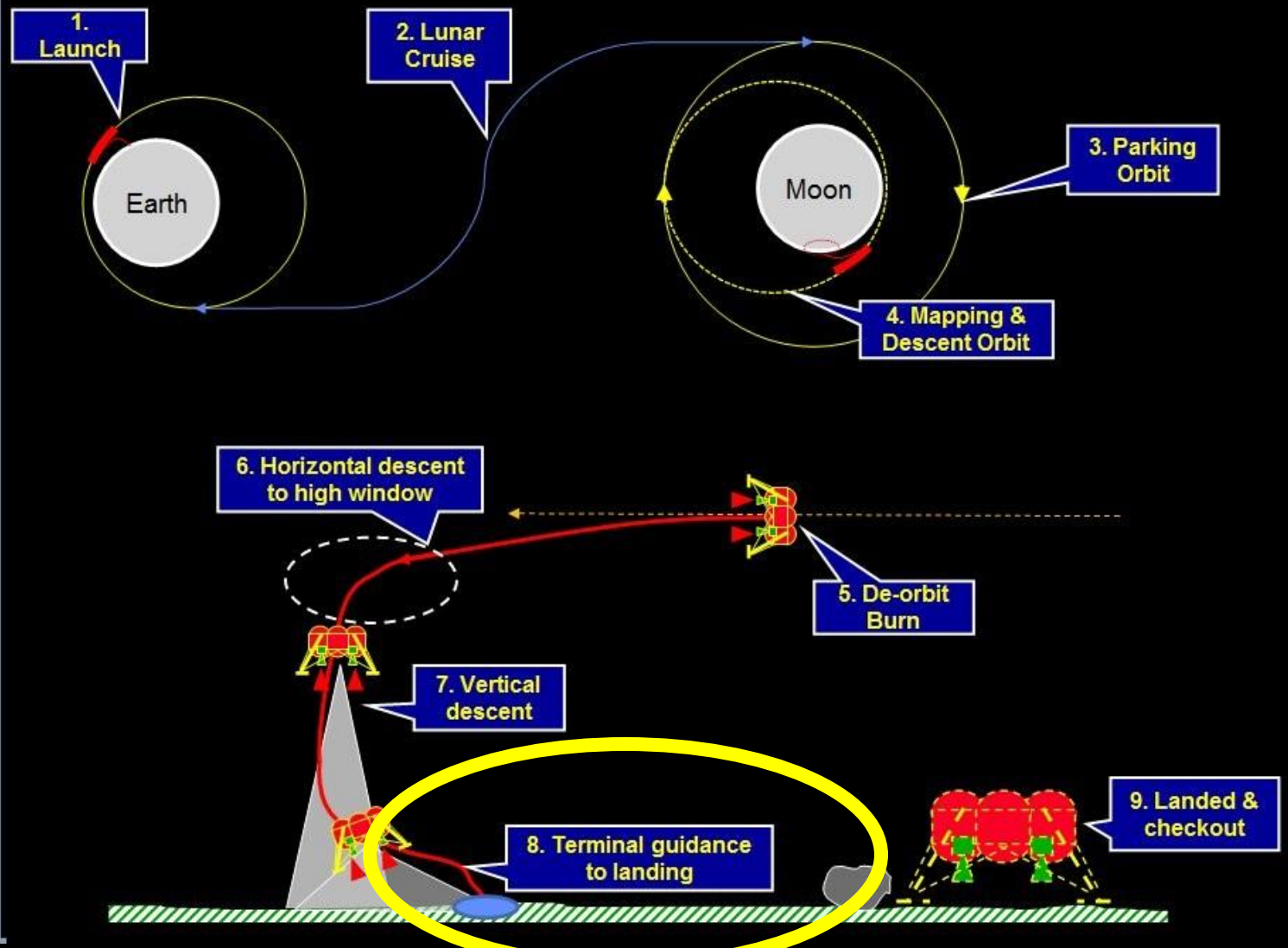
- Attempting to land at the South Pole.
- A previously unexplored area of the Moon.
- The two main reasons to look at it scientifically are:
  - Drilling to obtain and analyse rock samples.
  - Testing of scientific method called low frequency astronomy
- It is also a place where future manned missions could potentially go.

Landing on the Moon



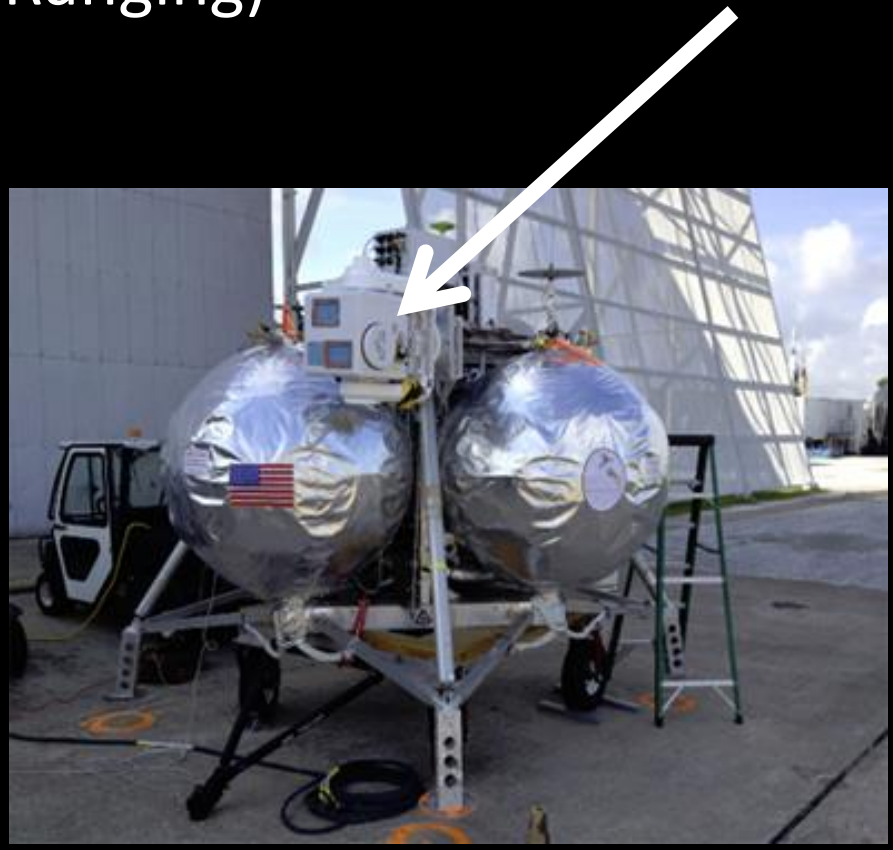
- The Apollo missions consisted of
  - some hard (impact) landings
  - some manned landings.
- All the landings had of course been pre-calculated…
- but they did need real time corrections.
- With added complications due to the landing site being on the Moon there may be a better way of guiding a lander to its site

Currently the planned sequence of events for Lunar Mission One is as follows:



Automated Landing

- NASA is currently developing ALHAT (Autonomous Landing and Hazard Avoidance Technology).
- This makes use of advanced technologies such as LIDAR (Light Detection and Ranging)
- And other surface-tracking sensors.
- Advantages
  - any lighting conditions
  - navigate to “pre-mission landing aim point”
  - Autonomous but will also have a manned controller



Visual homing

- This is another method that can be used to aid the descent of a lander.
- It requires a series of images taken along the planned trajectory in order to monitor deviations from the flightpath.
- This application is useful for many stages in the mission.
  - the initial mapping of the moon
  - the final terminal guidance stage

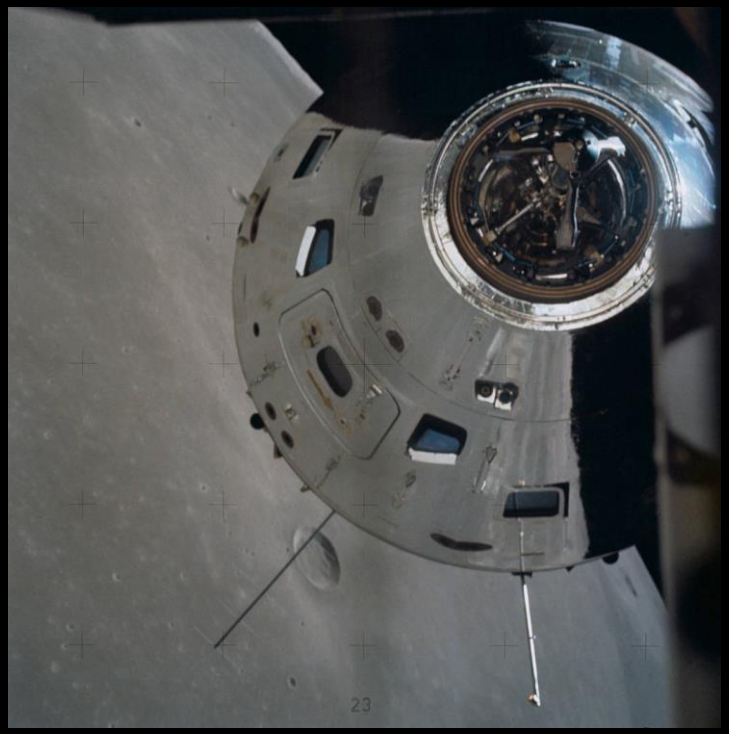
- It does require
  - good visibility at the landing site
  - the taking of the images
  - the actual landing to happen at exactly the same point in a lunar phase.
- In addition it requires some sunlight to be reflected off of the target location so unlike ALHAT cannot be used in any lighting conditions.

Precursor missions

- The series of images would need to be obtained for visual homing to work.
  - Easy on the Earth …
  - Tricky on the Moon
- It is likely that these images of the exact target area do not exist in enough detail for use.
- Therefore a precursor mission is needed.
- This will drive up project costs.
- Could be kept down by the use of newer technologies.
- All of this added to the complications on the previous slide makes it a rather difficult method to use when landing on the moon.

Site selection

- Site selection is very important to any lander project.
- The mission is over if the lander does not land.
- Chosen sight must be carefully preselected.
- Then it can become the pre-mission landing aim point for the ALHAT or visual homing technology.



Criteria for selection

- The key criteria to consider when selecting a landing site are
  - The steepness of the slope
  - Roughness features and other hazards on the surface
  - The availability of sunlight for solar power
  - The distance to get to a site
  - The availability of a direct line of sight to earth for communications
- Other features specific to Lunar Mission One are
  - ease of drilling
  - science value
  - archive survival
  - manned exploration value

Slope Steepness

- Slope steepness is one of the biggest potential hazards.
- It becomes a hazard when the steepness is greater than 15° steepness.
- A lander not in the correct position…
- Mission failure!

Roughness Features

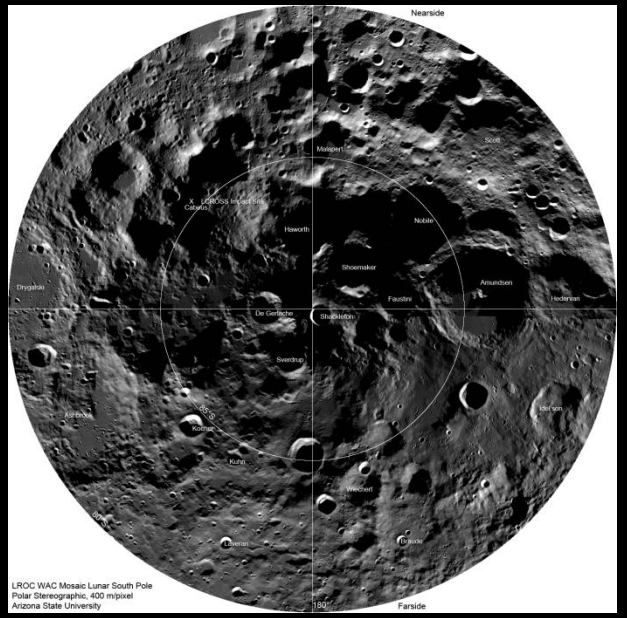
- Boulders commonly found on the lunar surface.
- Your landing gear determines the height at which roughness features cause a problem.
- One tiny stone wont have much of an effect.
- A 2m high boulder would.
- Roughness features must be identified as best as possible.

Illumination and Shadowed Terrain

- A lunar lander requires some kind of power source.
- No constant source of light at most places on the surface.
- A lander would only get roughly 14 Earth days worth of constant light before facing roughly 14 earth days of constant darkness.
- Punishing night time and winter temperatures due to a lack of an atmosphere.
- The lunar South Pole can achieve near constant levels of sunlight .
- Including any shadowed terrain as well.
- Proving a balance between all factors must be found.

Distance and direction

- This factor is less important to consider.
- Already in direct line of sight to the earth,
  - there is no possibility of using a lunar satellite for communication.
- Need to consider what a candidate landing spot might look like from an approaching spacecraft at various distances away.



NASA and the LMMP

- NASA doesn’t currently have a core interest in the Moon.
- They have however set up the Lunar Mapping and Modelling Project (LMMP).
- This is run by managed by NASA's Exploration Systems Mission Directorate and is a collaborative development effort across NASA and other organizations.
- The online portal for the project shows a map of the Moon and allows the user to scroll around the site and put various layers of data on top of the surface allowing you to see the moon in a variety of views.

LMMP and Lunar Mission One site selection

- The LMMP portal mainly holds data from the Lunar Reconnaissance Orbiter (LRO).
- Most of the data is publically available.
- There are some features which are only available with an account.
- “considered for those users who can demonstrate a justifiable need to access the features not available to the general public. ”
- Lunar Mission One clearly has a justifiable need as they are going to be using the LMMP for exactly what it was designed for.

Criterion One-Slope Steepness

- This is one of the easiest criteria to look at.
- The LMMP portal offers a slope tool.
- Data can be accessed using the slope tool.
- The slope at and around a target area can be calculated.

Criterion Two-Roughness Features

- The LMMP portal offers a search tool for lunar rocks.
- The target areas can be assessed for rocks which may be a hazard.
- Not the easiest feature to use.
- Cannot be guaranteed that features haven't been missed.

Criterion Three-Illumination and Shadowed Terrain

- We already know from studying the lunar south pole that the levels of sunlight are more than elsewhere on the Moon.
- Current sun angle information.
- Sun angle calculation for a particular date or time.
- The spacecraft and its solar panels don't need to know the accurate sun position.
- But do need to know the amount of sunlight available over a year to power the lander.
- This means that it will be hard to use the LMMP to asses the level of sunlight at each landing site.
- You can however use the crater search available on the LMMP portal to assess for shadowed terrain.

Criterion Four-Distance and direction

- The marker tools can calculate the distance between two points.
- The graticule can assist in direction calculations.
- There is already a shortlist of possible sites so these two factors are less important.
- Useful to measure the distance and direction of the sites from other objects if required.
- Plus actually locating the sites on the portal in the first place.
- The LMMP cannot be used accurately enough to predict what each candidate landing spot might look like from an approaching spacecraft at various distances away.

Limitations

- The LMMP does have its limitations with regards to accuracy.
- For instance:
  - the lunar rocks search tool may not have the ability to pick out every single rock on the surface.
  - Data is not always applicable to the present day and to making future predictions.
- We can make assumptions about the data, in the future it may not remain the same.

Crowd Sourcing Solutions

- Utilising people on a large scale to complete a project where it otherwise wouldn't be feasible.
- Three sections:
  - funding
  - people
  - equipment
- Lunar Mission One has already done some crowdfunding on the website Kickstarter.
- The ESA had intended to put a lander on the moon in 2018 but the project has since been stopped.
- 10 potential sites were identified.

Option One

- Give a selection of people one of the sites and ask them to use the LMMP portal to check through each of the four criteria.
- Advantages:
  - Saves time analysing
  - Task gets finished quicker
- Disadvantages:
  - Requires more people
  - Requires training or expertise of those people

Option Two

- Get a selection of people and assign them one of the criteria then get them to evaluate every landing site for each criteria.
- Advantages:
  - One person is able to make a judgement and create an ordered list
  - Each person can specialise
- Disadvantages
  - Some time could be wasted
  - Adds another level of complexity

Conclusion

- The LMMP portal is certainly useful.
- I would suggest option one
  - it requires more people to complete the project in a shorter space of time
  - it makes sure time isn't wasted
  - sites are easily excluded
  - allows for much easier comparisons

Education

UK national curriculum suggests:

KS2 pupils should be taught

- That the moon is approximately spherical and takes approximately 28 days to orbit the Earth .

KS3 pupils should be taught

- About gravity forces between the Earth and the Moon.

KS4 pupils should be taught

- The main features of the solar system.

Education

- Not anywhere is it stated that lunar landings or lunar missions are to be specifically taught.
- Any teachings on lunar landing sites and Lunar Mission One will remain extra-curricular.
- To many children the idea of a space mission they can follow throughout their student career increase their interest in space science.

Teaching with the LMMP

- The LMMP is free to use generally.
- It could be a good resource for teaching.
- Teachers can show their students an interactive map of the moon.
- Used in projects by those at KS5 and potentially KS4 .
- Though it may prove too challenging for those in a lower key stage.