Desert Robotics - Lunar Project Plan

Kelly Blasberg, Steven Blasberg, Jesse Hall, James Linnell, Alexander Nabavi-Noori, Parker Robinson - Palm Desert Middle

Leslie Barba, Mekai Ely, Rosaleen Escareno, Sonia Gonzalez, Stephanie Olivas, Giselle Quintana-Reyna - Abraham Lincoln School

DESERT ROBOTICS - LUNAR PROJECT PLAN

Desert Robotics Team 0083 developed the Lunar Project Plan to accomplish the required tasks for the Google Lunar X Prize competition along with several of the extra challenges. Read about the basic plan, the challenges, and rationale for completing them. Landing site selection and execution of the plan is presented to show how a real lunar rover might successfully win the Google Lunar X Prize.

CHALLENGES ACCEPTED & BASIC PLAN TO EXECUTE

Required Two Mooncasts: Use of Multiple Cameras & HI Bandwidth Comm.Technology

Extended Travel (5000 Meters): Travel to Illuminated Areas. Gerlache Crater Over Time

Bonus Task-Surviving Lunar Night: Good Insulation; Chose Fair Weather Landing Site

Bonus Task of Discovering Water Ice: Rugged Rover Design for Exploration

RATIONALE:

Mooncasts - Multiply cameras located on both robot rover and lander module will provide pictures/video necessary for completing mooncast requirements. Hi bandwidth transmission technology will support communication of Hi Def pictures and video back to orbiter and then earth from landing site.

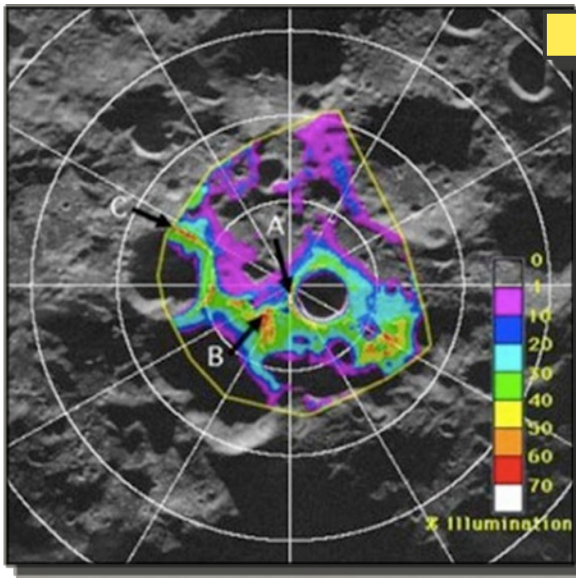
Extended Travel - Rover will have extended time on the lunar surface. Landing site, Aitken Basin at the South Pole, will give opportunity for distance travel to two illuminated areas for rover to recharge. Rover will traverse outside edge of Gerlache crater and make several trips from rim site to crater basin to explore for water ice.

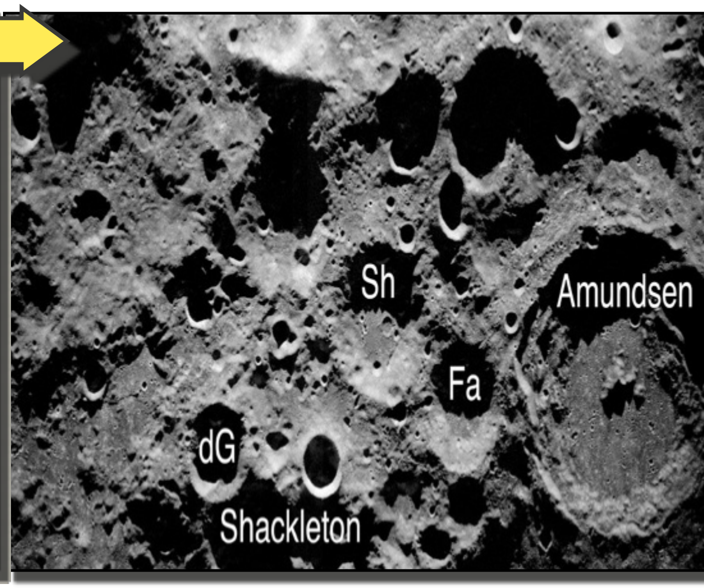
Surviving the Lunar Night - Rover will be well insulated to endure the temperature range of the South Pole area which is less than other landing sites. Recharging will be possible through most of the mission, including at least three times during the lunar night because of the high illumination of the South Pole area.

Discovering Water Ice - Rover will have time to explore Gerlache crater. Rover will have robust design to travel into best areas for discovering water ice. Subsystems will include instruments designed to identify location of water ice. Data from Clementine, LRO will aid in choice of locations to explore.

TARGET - AITKEN BASIN, SOUTH POLE

Lunar South Pole Illumination Studies [1] [2]





ADVANTAGES OF THE AITKEN BASIN FOR EXPLORATION

LOCATION! LOCATION! LOCATION!

HIGH PERCENTAGE OF ILLUMINATION PROVIDING

SOLAR ENERGY RESOURCE

PERMANENTLY SHADOWED AREAS FOR WATER/VOLTAIC TRAPS

MILD TEMPERATURE RANGE

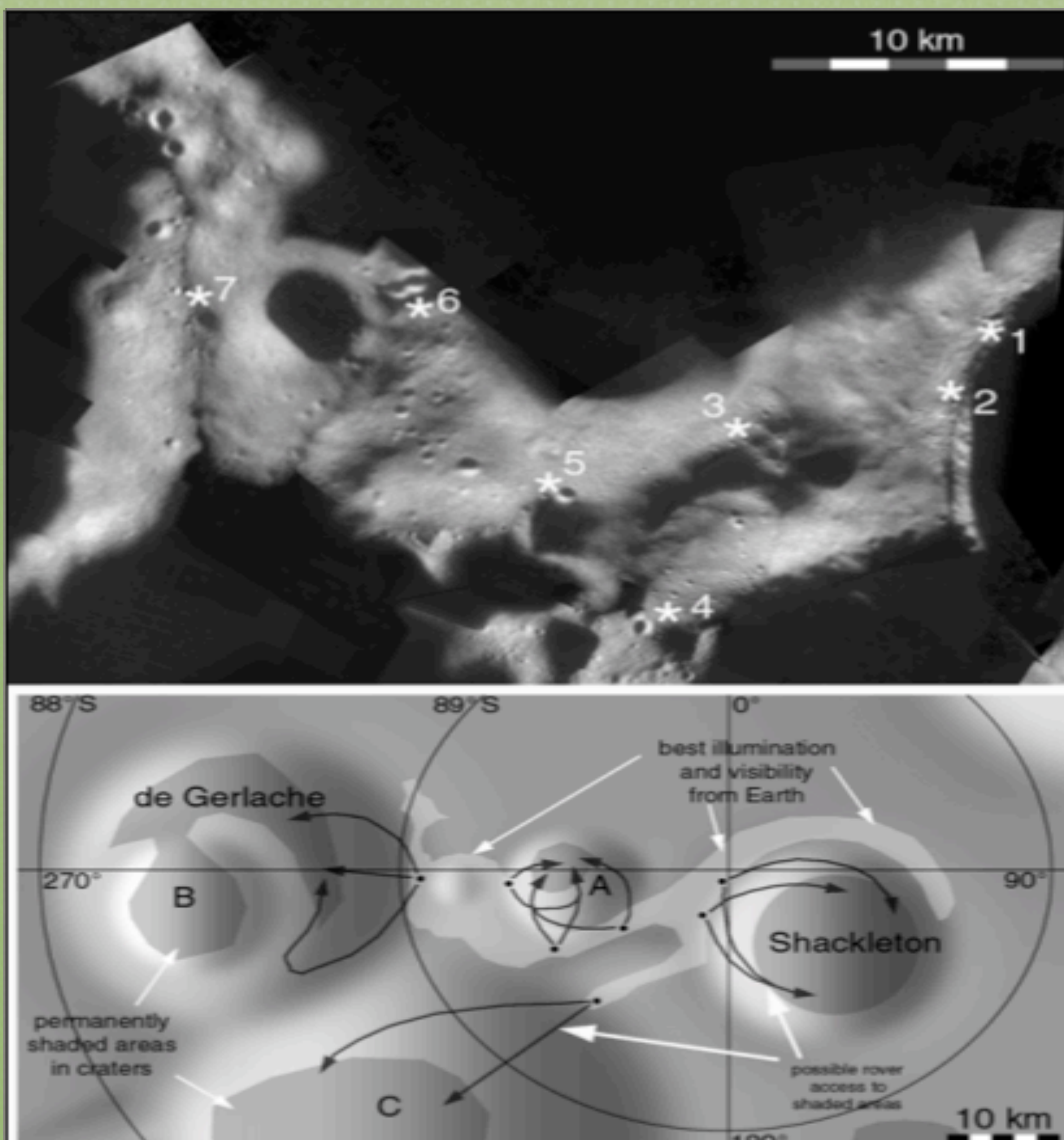
CLEMENTINE AND LUNAR PROSPECTOR DATA SUGGESTS THE PRESENCE OF WATER ICE IN SHACKLETON CRATER BASIN

The lunar South Pole offers many things for a rover exploration. The 'peak of eternal light' is a ridge between crater rims where the sun shines most of the time. A rover could use solar power cells to store power from here. There isn't just one area that is in constant sunlight but along the rim there are several spots where the sunlight shines on at least one of them all the time. [3]

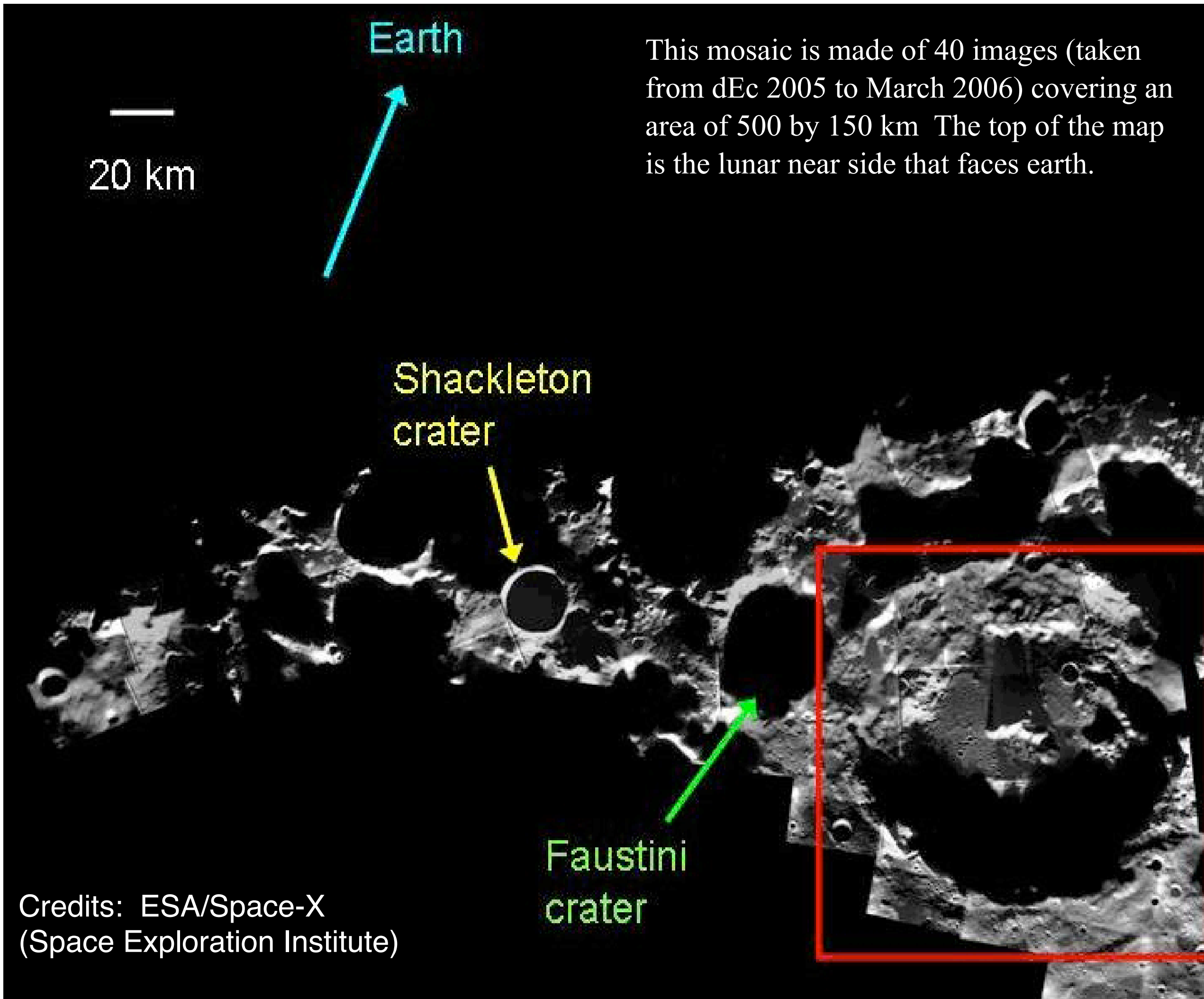
LANDING SITE:

Our target is the Aitken Basin at the South Pole, specifically the de Gerlache crater. (*7 on the map below) Our lander will put down near the rim of the crater in between Gerlache and Shackleton. Gerlache is an older crater that has a better chance of having collected volatiles, like water ice, and it has a large area to be explored, over 20 kilometers/12 miles. The larger the area gives a better chance of finding ice water, one of our missions. The crater also has shallower slopes for climbing down into the permanently shaded areas. Newer craters like Shackleton (*1 and *2 on map) have steep walls that might not be safe for exploration. Its young age also means there is probably less volatiles because its had less time to collect them. [2]

MOON: SOUTH POLE LANDING SITES P.J. STOOKE [2]



At the Moon's north and south pole, ice has been detected by two lunar missions, Clementine and Lunar Prospector. SMART-1 Captures New Lunar South Pole Images. [4]



The Shackleton crater is 19 km across at 89.9º south, 0.0º east. The southern part in in permanent shadow. It's name comes from the British polar explorer Ernest Shackleton.

The Faustini crater, 87.3º south, 77.0º east, is named after Arnaldo Faustinit (1872-1944) an Italian polar geographer explorer. The crater is about 39 km across. Readings from the Lunar Prospector mission indicated that there is a higher-than-normal amount of hydrogen there.

Near Shackleton crater is the De Gerlache crater named for the Belgina antarctic explorer Adrien de Gerlache (1866-1934). The floor of this crater is permanently shadowed. It is 32 km in diameter and is located at 88.5º south, 83.1º west. [4]

THE LUNAR DAY

The Lunar day/night lasts 27 earth days, 7 hours and 43 minutes. This is exactly the same time it take for one revolution around the Earth keeping one lunar hemisphere (called the near side) facing earth at all times. The rotation is approximately 14.5 earth days for one lunar day and 14.5 earth days for one lunar night. At the poles the sun does not rise very high in the sky at any time.

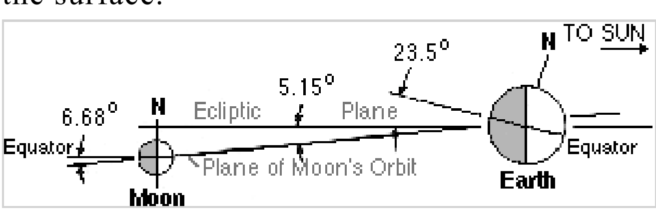
Studies from the Apollo landings show that the early lunar morning is the optimal landing time because of the ambient lighting conditions. The best being from noon of the 1st earth day until the end of the 2nd earth day. [5] Our rover will land during the early morning of the 2nd earth day of the lunar morning. This offers a good time for the rover to land safely because the terrain is easier to distinguish in the lighting conditions. At other times the terrain is washed out and the computer software has a harder time distinguishing obstacles. The first 5 earth days of the lunar morning and days 9 - 14 the times that lighting conditions are good for travel and exploration. During the lunar afternoon, days 14 -29, the surface is lit by earthshine, except for areas that receive continuous lighting at the south pole. [6]

TRAVEL PLAN

The robot will travel from the landing site along the rim of the de Gerlache crater. The solar power subsystem will be left on the rim to collect solar power. The main robot will be able to travel into the crater to the permanently shadowed areas to take core samples. The robot will travel back to the solar power station every four earth days when it is exploring the top of the crater slopes. It can use its own solar panels for power at several places along the rim of the craters where the light is shining most of the time.

During the noon period of the lunar day, the robot will have to rest. This time is when the ambient light is not very good for distinguishing objects on the landscape. It lasts for about 2 earth days. The robot will go into hibernation mode during this period. During the lunar day the robot will have time to explore into the de Gerlache crater, near by crater A and possibly to the Shackleton crater. The robot can travel between these craters during the 29 day lunar cycle.

The robot will take samples from many different places to look for water/ice. The more places, the more chance the robot has of finding water/ice. The drill on the robot can get core samples 1 meter down and the scoop on the front can turn up the loose regolith on the surface.



(Diagram by Paul Spudis.)

When you are at a peak at the Lunar south pole, the Sun is visible all the time. But if you stood in a hole at the south pole you would not be able to see the sun. It would be a permanently shadowed area. [7]

QUESTIONS ? ? ?

How do we detect ice on the Moon?

Radar and Neutron Spectrometers are science instruments that have detected the presence of hydrogen. This could be water ice. But it might be hydrogen combined with sulfur. [8]

How does a Gamma Ray and Neutron Spectrometer find ice?

The instrument uses Gamma Ray mode to measure the emissions from radioactive elements and can tell which elements are in the surface materials. Hydrogen is detected in the Neutron Mode and if there is water then there will be hydrogen. When cosmic rays hit the nulei of atoms on the surface of the moon, fast neutrons fly out into space. Slower neutrons run into frozen nuclei, like hydrogen, which makes them travel even slower as they move out into space. A spacecraft in orbit with a neutron spectrometer can measure the speed of the neutrons coming from the surface. If there aren't any medium ones, and there are a lot of slow ones, then there must be some hydrogen on the surface. The gamma ray sensor can detect high energy photons that carry the signature of the atoms, telling if it is oxygen mixed with the hydrogen. That means it is water. Another instrument called an ultraviolet spectrometer can measure for the presence of sulfur, which would mean the hydrogen is not part of a patch of water ice.

If you've traveled by airplane, your baggage was probably scanned by gamma ray and neutron spectrometers at the security checkpoint. They can detect the elements someone might use to make explosives and for traces of radioactivity. [8] [9]

How would ice have gotten to the Moon?

Comets, meteors, and water rich asteroids have landed on the moon. Water from inside the moon may come out at the poles as ice, frozen in cold dark areas. [8]

Why did the ice stay on the Moon?

The ice is caught in cold traps, areas that are colder than 80K and are in shadow all the time. The molecules of water are released when the comet, or meteor impacts on the Moon's surface. They bounce around from place to place. Because there is a near vacuum and lack of atmosphere the ice molecules go from a solid to vapor and hop off into space. But if they land in cold spots they slow down until finally they freeze solid and stay on the surface. These cold spots have to be in the dark. Sunlight hitting them would warm up the ice molecules and they would escape into space. That's why the permanently shadowed craters and underground areas in the polar regions are good places to look for water ice. The cold and dark keeps the water molecules stable. [8]

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