



# **NASA SPACE APPS CHALLENGE**

## **Rosario, Argentina**



### **Marco? Polo!**

Marco Polo is a project created with the purpose of collecting new data for the next generations of lunar probes and possible human establishments, focusing in the resources that the environment on the moon surface can provide us.

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# **Background**

## **1.1 Water**

Earth is the only place we know so far which supports life, and it is only possible because of its unique environmental conditions. Two of the main resources necessary are an atmosphere and water. Although it is possible to create a pressurized cabin and recycle oxygen so humans can survive and breathe this air, it is much harder to recycle water in space. For that reason, it is essential to know whether there is a source of water in case of a human extraterrestrial exploration establishment.

## **1.2 Energy**

Every process needs energy to be achieved. The main source of energy in the solar system that is certain that can be used is solar energy. However, solar energy is not available during night, so particularly on the moon, where nights last fifteen days, it is necessary to find an alternative source of energy.

On the moon, there is no own magnetosphere, so solar wind reaches its surface easily. When reaching rigolith, it is believed that some particles remain there. One of them is  $^3\text{He}$  (Helium three), a stable helium isotope which can be used in fusion reactions creating as much as 165 megawatt-hours per gram of  $^3\text{He}$ . Although there is still research to be done on the matter of fusion reactions, it is important to know if the amounts of this isotope are considerable for a future mission there, as well as if it is possible to bring it as fuel to Earth.

## **1.3 Lack of information**

When someone hears about current lunar projects, it is common to ask “Can humankind live there?”. There is much research done on colonizing the moon, but we do not know enough about essential resources as water and energy there, and the viability of them.

To solve this problem, it is necessary to expand our knowledge of the environment on the moon, and the resources we can found there.

# **Development of the project**

## **2.1 Objective and mission plan**

The project plan consists on launching a lunar satellite which would orbit the moon in a polar orbit, mapping its surface in properties as soil moisture, if any, concentration of  $^3\text{He}$ , minerals and topography of the terrain. This would be achieved with the technology of past lunar probes from different agencies, developing the same sensors with nowadays technology, and particularly taking advantage of the technology used in the SAOCOM 1a manufactured by Argentina to orbit the Earth, but to be applied on a moon satellite.

Clearly, the satellite would be transmitting constantly this data to Earth stations from a communication antenna and would also need a propulsion system for its manoeuvres.

## **2.2 Satellite sensors**

The satellite sensors are meant to describe the surface characteristics as explained in the mission plan. The sensors are based on those used by the Indian probe Chandrayaan 1, the Chinese probe Chang-E 1, and the Argentinean satellite SAOCOM 1a.

### **2.2.1 Lunar topography**

For mapping the moon topography, the probe will use two different sensors, a CMOS camera for a high-resolution map of the surface of the moon, and a laser rangefinder which would send pulses of infrared laser light towards the lunar surface and detect the reflected portion of that light.

### **2.2.2 Mineralogy**

For examining the minerals on the moon, it would be necessary to use one sensor the NASA has helped develop, the Moon Mineralogy Mapper, which is an imaging spectrometer, and three other sensors from different agencies, an X-ray fluorescence spectrometer, which maps the abundance of chemical elements Mg, Al, Si, Ca, Ti and Fe at the surface, a Sub-keV Atom Reflecting Analyser, developed by the ESA (European Space Agency) which maps the mineral composition on the surface using low energy neutral atoms emitted from the surface, and a near infrared spectrometer, which maps the mineral composition using an infrared grating spectrometer.

### **2.2.3 Helium 3**

The sensor used for measuring the amount of helium 3 is based on the method used by the Chang-E 1 probe, which consists on a multi-channel microwave that can measure the microwave thermal emission from the surface and evaluate the amount of helium 3 per unit area in the regolith.

However, the difference with Chang-E is that our satellite could map all moon surface thanks to its polar orbit, and the Chang-E only mapped part of it.

### **2.2.4 Soil Moisture**

For measuring water on the surface, there would be two sensors. A Mini-SAR which was developed by NASA and can measure the water ice on the surface, and a SAR antenna of about 35m<sup>2</sup> in L-band, similar to the one developed by the INVAP in Argentina for SAOCOM, which can measure the water up to 2 meter deep in the surface. Both sensors work transmitting polarized radiation and monitoring the scattering.

## **2.3 Orbit**

As the satellite is designed for mapping all surface, the ideal orbit should be polar, in order to overfly every point of it, thanks to the moon rotation. For achieving this class of orbit, it would be necessary to perform a series of manoeuvres. Initially, the satellite has to be put in a polar orbit around Earth. After it, the probe will be put in a geostationary transfer orbit, and in a sequence of fuel burns, the orbit will be increased until reaching an apogee similar to the apogee of the moon. Then, when passing nearby the moon, the vehicle would need to decrease its speed in order to be inserted in a moon orbit. Once inserted, a new sequence of burns would reduce the orbit until the desired distance to the surface.

However, once in polar orbit, the orbit would not be stable, and it will be necessary to improve a low-thrust control system consisting in an engine and around a ton of fuel, so it could be correcting the orbit, using the algorithm developed by Missouri University of Science and Technology (see sources), for maintaining it for up to 2 years. After it, the satellite could be inserted into a more stable orbit and keep monitoring other areas of the moon.

## **2.4 Energy**

All sensors can be powered by solar energy and batteries, which can be charged during sun hours. The satellite orbit is calculated to be completed in less than three hours, so the time in dark can be powered alone with batteries.

## **2.5 Fuel**

As commented before, it would be necessary to carry enough fuel to be inserted into lunar orbit and to maintain that orbit. It is estimated to use one ton for maintaining the orbit and one ton for getting to the moon.

## **3.1 Monitoring and uses**

Because of the satellite polar orbit, the probe would be able to map the whole moon and monitor the concentration of minerals, water and helium 3 for a prolonged time, providing enough information to evaluate the best locations for future landings.

This new data of the helium 3 can be used, with cooperation of the NASA satellites ARTEMIS, to gather valuable information for a better understanding of the solar flux and the possibility of the helium 3 as a powerful source of energy.

This would be the first time ever a satellite maps helium 3 in all lunar surface, as well as the first lunar satellite to incorporate the SAOCOM technology. Combined with all its sensors, it is an integral and unique project that could bring valuable information from the moon, as Marco Polo did the same bringing information from Asia to Europe some centuries ago.

## Sources:

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