Elcano Moon Camp Team

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Project description

We call our Moon Camp 'Elcano', in honor of the Spanish navigator who, after many hardships, managed to complete the first circumnavigation of the Earth from 1519 to 1522. His adventure is comparable to human landing on the Moon for the challenges and achievements that both have represented in the history of exploration.

Campsite location

At lunar south pole, there are impact craters whose depths are not reached by sunlight and, besides being of interest for research on the origins of the solar system, contain frozen water inside. Among them, we chose Shackleton Crater because the peaks located on its rim are exposed to sunlight almost permanently, while its interior remains in darkness and will provide us with water and protection. Along the crater's rim, we will place photovoltaic panels, and inside it, we will locate the different camp modules connected by sealed corridors. Outside the base, we will construct the platform for landing and takeoff of spacecraft.

Modular Design

In the initial phase, we aim to accommodate 4 astronauts, but gradually, new spaces can be added and connected to welcome more personnel. We designed the camp with semi-spherical modules connected in a star shape and with 2 outside exits for safety reasons:

- **Central Module - Kitchen/Dining Room/Gym/Common Room:** 60m2 usable area (semi-sphere radius 4.60m).
  It connects to the rest of the modules.
- **Module 1 - Garage:** 60m2 usable area (semi-sphere radius 4.60m)
  This module will serve as a parking space for rovers and will have direct access to the outside.
- **Module 2 - Workshop/Control Room:** 45m2 usable area (semi-sphere radius 4.10m)
  This area will be the repair workshop and control center for the photovoltaic panels, telescopes, communication devices with Earth and the GATE, etc.
- **Module 3 - Greenhouse:** 114m2 usable area (semi-sphere radius 6.2m)
  For aeroponic and some hydroponic crops.
- **Module 4 - Laboratory/Infirmary:** 25m2 usable area (semi-sphere radius 3.20m)
  This space will be used for conducting experiments and will also house cylindrical tanks for anaerobic digestion of feces and the microbial reactor for biomass production from methane. It will have robots for complex emergency surgical interventions and an outside exit.
- **Module 5 - Bedroom/Bathroom:** 30m2 (semi-sphere radius 3.40m)
  This module will be internally separated into private cabins with horizontal beds to which "sleeping bags" will be attached for the crew. It will also have a bathroom.
- **Corridors:** Tubular and semi-spherical. Usable width of 1.20m (semi-sphere radius 1.90m)
  The corridors will have airlock doors at their ends.

For the psychological well-being of the astronauts, we will use artificial intelligence and project images of a moving natural terrestrial sky and change the intensity and color of the lights throughout the day to mark circadian rhythms. Additionally, we will reproduce familiar sounds such as the sound of flowing water. The choice of different colors and textures on walls and furniture will allow us to create an atmosphere of warmth and relaxation. The presence of a robotic pet, a dog, with which we can interact and with a pleasant touch to be stroked, will also contribute to the emotional balance of the crew. The proximity of the Moon to Earth allows for video conferences to maintain contact with loved ones.

Construction

The modules will be constructed by rovers transported from the GATE along with deployable domes. On top of these domes, using 3D printers, the rovers will begin building an infrastructure in a networked pattern with regolith, following the "cellular printing" method proposed by the company "Foster and Partners" in collaboration with ESA. This is a lightweight but sturdy structure that will be filled with more lunar regolith over time.

The interior walls and floor will be coated with panels of different textures and colors. The material used will be BSC, a compound of multiple micrometer-scale particles formed by regolith and water bound by biopolymers (proteins manufactured by genetically engineered microorganisms). It is a material with high durability, high resistance, and high rigidity. Using the same construction method, panels will be made for interior space separation and furniture construction. The floor will offer some resistance for better traction for the astronauts.

Astronaut protection

The camp's location inside the crater and the modules coated with regolith will shield astronauts from dangers due to the absence of atmosphere: meteoroids, extreme temperatures, and solar radiation. The sealed corridors will prevent depressurization in case of potential issues in any of the modules.

Daily routine of astronauts

Similarly to the ISS (International Space Station), our camp will follow the UTC 0 time zone.

SCHEDULE (UTC 0)	ACTIVITY
6:00	Wake-up and breakfast
7:00	Base maintenance and research
10:30	Exercise
12:00	Lunch and rest
13:30	Base maintenance and research
16:30	Exercise
18:00	Personal hygiene, dinner and rest
19:30	Organization meeting and writing of daily report for ESA
20:30	Video calls with loved ones / Leisure
22:00	Rest

Similar to the gym on the ISS, we will use three exercise machines: a Cycle Ergometer (stationary bike), a tethered treadmill, and the ARED (Advanced Resistive Exercise Device), which allows us to work all muscle groups.

Food

Although initially we will rely on packaged diets, we will eventually become self-sufficient and achieve the 2800 Kcal needed for each astronaut thanks to a greenhouse. LED lighting systems with specific wavelength lights will stimulate plant growth. We will opt for vertical aeroponic crops, which consume very little water as it is sprayed onto the roots, make the most of space, and minimize the risk of pests.

We will cultivate soybeans, potatoes, carrots, turnips, dwarf wheat, strawberries, and tomatoes. Using 8 rotating towers of aeroponics, we will produce 960 plants at different stages of growth, harvestable between 10 and 30 days. We will continue researching to find genetically modified varieties better suited to lunar conditions. We will also have some hydroponic crops (watercress and algae).

Additionally, we will break the monotony of meals with 3D food printers.

For astronauts, both enjoying meals and caring for plants are beneficial psychologically.

Foods can also help prevent diseases. For example, potatoes help combat cardiovascular diseases and reduce blood pressure, two problems we may encounter while in space.

Water

We will collect ice from the crater using rovers with pressurized tanks to liquefy it and prevent water loss through sublimation. We will also extract water from lunar regolith through filtration or distillation, but these processes are more complex due to the large quantities of lunar soil required and the higher energy expenditure involved.

Additionally, we will collect and purify water from urine and respiration through osmosis.

Electricity

We will construct photovoltaic panels using iron pyrite obtained from the regolith and install them on the crater's edge. A production area of approximately 0.4 hectares will generate between 84 and 120 kilowatts. We will maximize their performance with a heliostat system that will orient sunlight towards the panels.

We will also generate electricity using radioisotope batteries (protected with reinforced lead containers) and fuel cells (which directly convert chemical energy ($2 H_2 + O_2 \rightarrow 2 H_2O$) into electricity, water, and heat.

Rovers will operate using solar panels and fuel cells.

Air

In the habitable domes, we will create a breathable atmosphere.

Oxygen will be produced by the plants and algae in the greenhouse, which will utilize CO_2 from the astronauts' respiration and water from their urine for photosynthesis.

Furthermore, the iron and titanium in the lunar soil enable us to catalyze the electrolysis of water extracted from the regolith itself (in high-temperature furnaces), allowing us to produce oxygen, hydrogen, and methane through various industrial processes, using solar radiation and CO_2 exhaled by the astronauts. These processes will yield solid byproducts rich in silica and metals, which in turn will be useful resources in lunar exploration.

Human waste

We will decompose astronaut feces anaerobically using microorganisms in small cylindrical towers measuring 120x10cm (based on technology developed by the University of Pennsylvania). The methane obtained will allow us to cultivate ´Methylococcus capsulatus´ bacteria in a reactor and produce biomass rich in proteins and fats that will be edible for astronauts or for insects we may choose to breed in the future.

To address the disposal of menstrual waste, further research will be necessary.

Additionally, studying the trash bags left by the Apollo missions will allow us to understand how exposure to lunar surface conditions has affected the bacteria present in astronaut feces and their decomposition. This will help us find new solutions for the disposal and/or utilization of our waste.

Regarding space suits, we will need to devise better solutions than diapers, like the Maximum Absorbency Garment (MAG), to facilitate multi-day expeditions outside the base.