From Sci-fi to Reality: the Future of Lunar Infrastructures

Introduction

The Moon was the first ever challenge humanity had to overcome in order to begin its space race. However, after having been conquered more than 50 years ago, our natural satellite did not receive as much attention as it should have. Indeed, although we put our biggest effort on the colonization of Mars, creating permanent infrastructures on the Moon surface is not only beneficial for further space exploration and expansion, but would also represent a first challenge that would help scientists develop the necessary expertise and empirical experience to prepare future settlements in other planets. Fortunately, thanks to mission Artemis, NASA, together with SpaceX and ESA, hopes to establish prolonged human presence on the Moon, creating a proper base, starting in 2024. This article will explore the challenges that the mission will face in the next few years, as well as possible further development of lunar infrastructures.

Artemis: the new age of lunar development

Mission Artemis (named after the Greek goddess of the Moon) will see a direct collaboration between NASA and SpaceX: the latter won a $2.89 bln contract to develop and manufacture a modified variant of the Starship for Lunar Landings, called HLS (Human Landing System), which will be transporting astronauts from the lunar orbital gateway to the base camp on the surface, as well as providing a living space for the astronauts during the first landing. Conceptually, the HLS created for mission Artemis has the same structure of the landing module that will be used for future missions on Mars, except for heat shields and airbrakes which are unnecessary given the lack of atmosphere on the Moon. Moreover, the module will also be equipped with a special landing thruster that will be used on descent and takeoff from the lunar surface. The mission also expects the creation of a base on Moon's orbit, which will be called Lunar Gateway and will host the astronauts that are not currently working to establish the settlement on lunar surface.

Early stage of first lunar infrastructures

The Artemis Base camp is planned to be developed near the south pole of the Moon in a region called the Shackleton crater. Shackleton crater has a very unique location, as the peaks along the crater's rim are exposed to almost continual sunlight, while the interior is perpetually in shadow. This fits NASA's criteria for the ideal Base camp position. Indeed, these are the most important two key features: the site must bask in near-continuous sunlight to power the base through solar panels, and it must offer easy access to areas of complete darkness that hold water ice. Having access to ice will help the Artemis Base camp to achieve its goal of self-sustainability as the base camp won't have to depend upon an external supply of water and it can also generate its oxygen by breaking up H_2O molecules.

Artemis Base Camp itself would be a lunar surface habitat that is planned to host four astronauts. Life support is at the top of the priority list for the base camp. The facility will require infrastructure for power, waste disposal, and communications, as well as radiation shielding and a landing pad, which according to NASA should be separated from other base camp buildings and at a different elevation to prevent the HLS from spreading lunar debris near the habitable zone, potentially damaging solar panels or scientifically relevant sites. Moreover, being on the Earth's side of the

Moon, the Artemis Base Camp would easily be able to communicate with NASA's engineers to exchange relevant information.

To enhance astronaut mobility in the base camp or in general for exploration purposes, the mission also involves the deployment of a lunar terrain vehicle and a habitable mobility platform, designed to support trips away from lunar surface for up to 45 days. Finally, NASA plans to also include in the project of the base a "hopper" that could deliver technology payloads across the Moon, under the direct command of the astronaut crew, as well as a lunar far sight radio telescope that would be operated directly by the basecamp crew.

Long term opportunities

Aside from the obvious benefits that this mission has in the relatively short term (10-15 years), further investments in lunar infrastructures can have huge benefits in the long run. First, although it might appear trivial, we must highlight the importance of the know-how and the expertise that will be developed by operating to make somewhat habitable such a hostile environment: as we know, technological and scientific progress is an exponential process, meaning that although the head start might be slow, the further we push our ambitions, the quicker we will achieve incredible results. Moreover, if we think in "educated science fiction" terms, several possibilities lie on our natural satellite: from the possibility of lunar mining to create rocket propellant directly on the Moon, to the possibility of building a skyhook which would orbit the earth and drastically reduce the amount of fuel needed to leave the atmosphere and start traveling around the solar system. The latter, as absurd as it sounds, is in fact possible to build entirely with the scientific and engineering knowledge that we possess as of today.

As always, the only limit to humanity is its imagination.