#27 - A giant leap towards sustainable energy generation: Space-Based Solar Power system for Moon assets

Since the end of Apollo Era, the Moon has received few visitors to its surface. Recently however, several agencies have renewed their interest in the Moon with the goal of using it as a gateway to reaching Mars and to study its South Pole region, where water ice is present. Continuous power supply is crucial for any lunar settlement, but the option of placing solar panels on the lunar soil faces challenges in perpetually shadowed areas and potential interference from lunar dust. This is where Space-Based Solar Power (SBSP) comes into play.

Mission Objective

Lunar SBSP involves collecting power in orbit and transmitting it to the surface of the Moon. This approach offers advantages such as the possibility for orbit optimisation to maximise sunlight reception, providing solar energy to permanently shadowed regions and avoiding atmospheric losses that occur on planets like Earth, where about 70% of incoming sunlight is absorbed. In this context, DSE Group 27 has been commissioned by the European Space Agency to design a Space-Based Solar Power system for continuous provision of 1 Megawatt of power to assets at the lunar South Pole for 25 years.

System Design

After seven weeks, the team has selected a concept following a trade-off approach, and the detailed design of the different subsystems is in progress. It was opted to use laser transmitters for the beaming of power to the lunar surface. With this, the name of the mission has been determined to be LUMEN: Laser-based Uninterrupted Moon Energy Network. This network will consist of a constellation of 80 spacecraft, split over two mirrored Elliptical Lunar Frozen Orbits. The lowest point of the orbit will be above the lunar North Pole, and the highest point will be at the South Pole, allowing for long contact times of 17 hours. Doing so, at any time 67 out of 80 spacecraft will be able to transmit power, which reduces the power to be collected per spacecraft. Conversely, high pointing accuracy is needed at high altitudes for which an advanced closed-loop laser guidance feedback system was developed with fine steering mirrors. A Ritchey-Chrétien telescope is used to collimate the laser, limiting beam divergence and achieving a spot size of 11 m at an altitude of 14000 km. The power receiver on the lunar south pole consists of an 80 m diameter circular photovoltaic laser power converter fine-tuned to the specific wavelength used. The power in orbit will be collected using concentrated photovoltaics, consisting of flexible Fresnel lenses that concentrate the solar flux by 8.5 times. The solar panels will be deployed using Stretched Lens Array Squarerigger (SLASR) developed by NASA. Each spacecraft will collect 130 kW, with a solar array area of 400 m^2, placing it in the same range as the James Webb Space Telescope. The total mass of each spacecraft will be around 600 kg.

In the coming two weeks, the team will assess the performance of the selected design, its sustainability, and perform an extensive exergy analysis (energy used for production versus energy generated) aiming at comparing the LUMEN concept to other means of producing energy on the Moon. Furthermore, the sensitivity, as well as the scalability to other celestial bodies of the design, will be addressed.