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NEW END-TO-END LASER POWER TRANSFER ARCHITECTURE FOR GLOBAL ENERGY PROVISION ON THE MOON

Abstract

Power scarcity is one of the main roadblocks in the diffusion of sustained and sustainable lunar activities and in the development of a thriving lunar economy. The majority of the past, present and forthcoming missions cannot endure more than a handful of lunar days due to current limitations of power supply and distribution technologies, and are prevented from exploring efficiently and prolongedly the resource-rich permanently shadowed areas. Laser power transfer (LPT) from orbit to the surface has been proposed as a potential solution. However, the viability of such solution has been negated by low conversion efficiencies, limitations in pointing accuracy for long ranges, and rapid degradation of high-power lasers in the space environment. This work presents a new orbital LPT architecture enabled by the advancements in laser and photovoltaic technology pursued by Volta Space Technologies. The main elements of the architecture are a spaceborne high power laser capable of producing multiple hundreds of watts with near-diffraction limited beam propagation properties and high wall plug efficiency, a laser power converter receiver capable of operating under non-uniform illumination at conversion efficiencies that are two times higher than commercially available photovoltaics, and a closed-loop pointing system enabling reliable and accurate power transmission from hundreds of kilometers with centimeter-scale beam displacement control. This scalable architecture can provide tens to hundreds of watts to users located anywhere on the surface of the Moon and integrating the receiver. Such amount of power can enable night survival of many short-term lunar assets such as rovers and landers. Constellation feasibility will be introduced describing the concept of operations and coverage maps for energy availability, and discussing the main use cases and advantages compared to present-day alternatives such as batteries and nuclear devices. The main features of the key building blocks will be shown, including the outcomes of a comprehensive environmental testing campaign conducted to consolidate performances and stability in relevant environment. Finally, the results of end-to-end demonstrations will be shared, providing a full overview of the current status of this new technology and the prospects for future utilization and adoption.