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TOWARDS THE COMMERCIAL DEVELOPMENT OF ORBITING REFLECTORS: A TECHNOLOGY DEMONSTRATION ROADMAP

Abstract

The delivery of global clean energy services is a key challenge for the 21st century. With the rapid expansion of the solar energy sector, orbiting solar reflectors can enhance the utility of solar power farms, in particular when consumer demand is high but output is low. Recent studies showed that a constellation of reflectors orbiting at an altitude of 1000 km, with equivalent diameter of 1 km, can deliver up to 36 MWh of energy per pass over a large solar power farm. However, before this concept can reach full-scale commercial deployment, intermediate steps are required to increase its technology readiness level. A roadmap for technology demonstration will be discussed in this paper.

First, laboratory demonstrations will be discussed to validate critical technologies, such as manufacturing and deployment of the reflective membranes in vacuum. Analysis of the membrane deformation due to attitude slews can be performed with scaled models and properties such as thermal cycling degradation and membrane wrinkling can be investigated experimentally.

The next step will consider the use of high altitude balloons as a low cost initial demonstration phase. Then, deployment of a small-scale reflector from a sounding rocket at dawn or dusk to illuminate an instrumented test range will be considered. A trade-off of sounding rocket apogee, reflector size and pointing requirements will be presented. It is expected that control moment gyros are used to slew the reflector and maintain pointing during the short period of free-fall descent. This will allow direct measurement of the intensity of reflected light on the ground and verification of the accuracy of numerical models used in the design phase. Model verification will be key to reduce the risk of deploying a full-scale commercial constellation. A full in-orbit demonstration can then be considered by deploying a reflector at an altitude below the International Space Station (for short orbital lifetime). This will allow a full end-to-end test of deployment, operation and attitude control of the reflector to reflect sunlight to different Earth sites for measurement of reflected light intensity. Moreover, in-orbit fabrication of the reflector will be considered as a demonstration of full-scale manufacturing of a commercial constellation of reflectors.

The paper will therefore detail the requirements and expected results for each development phase, presenting specific case studies for the orbital and suborbital demonstrations. From this analysis the expected timescale leading to the full-scale commercial deployment of the technology will be presented.