IAF SPACE POWER SYMPOSIUM (C3)
Solar Power Satellite (1)

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SPACE MIRROR ORBIT FOR MUNICIPAL STREET LIGHTING

Abstract

Is it possible to replace the electricity used for municipal street lighting in the evenings with reflected sunlight from mirrors in space? As described here, the answer is yes. It is both technically and economically possible by placing a 4 mirror satellite constellation in a sun synchronous polar 4 hour orbit at an altitude of 6,540 km. Imagine the 4 satellites spaced by 90 degrees and imagine the polar orbit tilted by 30 degrees toward the night side of the terminator. Then each mirror satellite can pass over municipal ground sites in the northern and southern hemispheres for 1 hour in the evening. The 4 mirror satellites can then pass over in succession for 4 hours from 6 pm until 10 pm in the evening. A first question is then: How large will the illuminated area be on the earth from a mirror satellite? The sun subtends an angle of 0.5 degrees. The divergence angle from a flat mirror will then be 0.5 degrees. So for a distance from the mirror to the earth of 6,540 km, the spot diameter will be (sin0.5)x6,540 = 57 km. This is a reasonable diameter for a city. The target area is then (3.14/4)x57x57 = 2,550 sq km. The next question is how much power will be incident on the target site with a full moon illumination intensity of 0.6 mW per sq m as might be typically required for evening street lighting? The answer is 0.6 x 2,550 kW = 1,530 kW = 1.53 MW. Then the last question is: how big is the space mirror? Given the solar intensity of 1.35 kW per sq m, then the mirror area will be 1530/1.35 = 1133 sq m and the mirror diameter will be (3.14/4)x D2. So D = 38 m. The mirror diameter is 38 m. Now note that Harris offers a 22 m diameter reflecting communication satellite antenna. Two 22 m diameter mirrors on either side of a center body satellite could have an equivalent diameter of 1.41x22=31 m. Now what about cost? Note that there can be 2 ground sites targets per orbit in north and south hemispheres per revolution and there will be 6 revolutions in a 24 hour period. The cost question will be discussed in more detail at the conference but the preliminary answer is that a pay back time of less than 10 years is plausible.