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Space Elevator as Transportation Infrastructure to Access Space (3)

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SECONDARY TETHERS

Abstract

The apex anchor is the name of the end of the space-elevator tether 100,000km from Earth. The tether rotates with Earth, and so the apex anchor travels at 7.7km/s, fast enough to escape Earth's gravity. However, the directions available are all in the plane of the equator. To achieve travel in any direction, secondary tethers are proposed that rotate about the apex anchor in a plane orthogonal to the equatorial plane. A tether 10,000km long, made of the same material as the main tether, can be rotated fast enough to achieve a velocity at the end of 10km/s. Rotation in two planes is enough to allow spacecraft to depart at least once a day in any direction, by analogy with astronomical units of declension and right ascension or longitude and latitude on Earth. Mathematical analysis shows that a system of two pairs of tethers will work well. Each pair consists of two tethers joined at the apex anchor and rotating in synchrony at the rate of one rotation every 105 minutes. One pair rotates in the opposite direction to the other pair. It is possible to adjust the speed of rotation to get the desired timing for precise control of the spacecraft's direction of travel. Two pairs are needed to provide a suitable reaction mass so that the apex anchor and the main tether do not rotate. In addition, the two pairs of counter-rotating tethers can be used to minimize and control the gyroscopic effects. The estimated mass of the two pairs of tethers and support equipment is about 600 tonnes, well within the mass budget of the apex anchor, which is 1900 tonnes. A recent publication by Peet has shown how the main tether itself can be used to accelerate a spacecraft to 10km/s, and using a ramp to permit travel in any direction. The system of secondary tethers has the advantage that spacecraft to not have to travel at high speed along the tethers; they can proceed at a moderate pace and still gain the high velocity needed. The main message is that multiple methods exist using space elevators to achieve the highly desirable goal of fast access to the whole solar system or even beyond, with travel times of a few months instead of years.