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MULTI-STAGE SPACE ELEVATOR – THE BENEFITS OF SCALING

Abstract

Realizing the space elevator requires either an order-of-magnitude improvement in material strength or a different approach. To use a weaker material, we need a way of supporting the tether at stages above the atmosphere. The number of stages depends on the strength of the material: a weaker material requires more stages to support the tether's weight. With five stages, the tether can be made of Torayca carbon fibre yarn, which is commercially available. With two stages, a material strength is needed of less than one third of the standard model proposed in the 2013 IAA study report.

A climber ascends the tether as in the standard model, except that there is an additional mechanism at each stage to allow it to jump over the supports. The multi-stage tether is still connected to the earth's surface, as in the standard model, so that it can use the earth's rotation to transfer momentum to the climber, which gently accelerates to orbital velocity at the geosynchronous altitude.

Above the atmosphere, the stages are supported by fast-travelling objects called bolts, which use magnetic levitation. In the atmosphere, they travel in evacuated tubes to minimize friction. Early prototype bolts developed for High Stage One have dimensions of 906050 mm and a mass of 0.4 kg, but scaling down their size by using more advanced electronics could lead to a substantial saving. This is because the size of the structure on the earth is proportional to the bolt size. By making a larger number of smaller bolts, the submersible structure in the ocean can be reduced in linear proportion to the bolt size while still enabling the bolts to travel thousands of kilometres into space. The submersible structure – known as the lower ambit – would need an ocean depth of 6000 metres with full-size bolts, but a 10:1 reduction in bolt size requires a depth of only 600 metres, which is well within current practice for the oil and mineral industries.