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Tethers in Space

TETHERS—what are they, how may they be used in space, what rationale does one have to use them?

A tether may look like a rope (braided strands), a hollow cylindrical rope (also with braided strands), a coaxial cable composed of multiple materials, and possibly other geometrical configurations to satisfy specific applications. In general, the length of the tether may be anywhere from a fraction of a kilometer to multiple kilometers. A question then arises regarding the lifetime of a tether in space. Studies have been conducted to illustrate the number of "hits" that a tether might sustain depending on its cross section, length, and altitude. This has driven the design of a long-life tether so that it may sustain multiple hits but yet operate satisfactorily.

The makeup of the tether is determined by its application as to whether it is a nonconducting or conducting system. The nonconducting tether generally is composed of multiple strands of high-strength materials. The multiple braided strands may form a tether of a few millimeters in diameter. On the other hand, the hollow cylindrical rope may have its diameter of several centimeters.

One of the most obvious applications of a nonconducting tether is its use in "towing." NASA illustrated this feature several decades ago. Recent studies supported by NASA have indicated the potential of using this concept to increase the orbit of a large mass—the International Space Station.

Under normal conditions, the Space Station's orbit decreases with time. It may be possible to increase its orbit by towing it, for example, by a Shuttle with a tow rope (nonconducting tether) of a few kilometers in length.

There are other ways of reboosting or deboosting a mass in space. With two masses tied together with a nonconducting tether, one mass swings with respect to the main mass. At the appropriate time the tether is severed, the masses separate, one is reboosted, and the other is deboosted. In this case, the tether is destroyed.

Conducting tethers may be used to reboost/deboost a mass (satellite, space object) or to provide power to this mass. Several studies have been carried out in the United States, Europe, and Japan to illustrate the features of an electrodynamic tether to reboost a space object. In this case, the tether is composed of nonconducting (for strength) and conducting (power-carrying capability) sections. To reboost the space object, the conducting tether, which may be several kilometers in length, is released from the space object and is deployed downward (toward the Earth). Current (power) provided by the space object flows along the tether and closes a loop with the external field, resulting in a force (thrust) to provide the reboost capability. This technique has been illustrated already by a joint U.S.–Italian project. For commercial uses, several factors need to be evaluated, such as the tether design, method of deploying the tether, multiple uses of the same tether, safety issues relating to power demands, and safety issues relating to tether release. The electrodynamic tether concept may also be used to generate power. In this case, however, as the power is generated, a "drag" force results that causes a decrease in the orbit.

Tethers have been illustrated and tested in the space environment for several decades. There have been numerous studies to confirm the tests and experiments that have been conducted in space. Innovative methods are being developed to utilize tether systems in an extension of their application to space transportation.

Several conferences have been held on tethers over the past decade. A few papers from a recent conference are provided to illustrate the broad scope of activities conducted in this exciting area.

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