Electrodynamic Tether at Jupiter. 1. Capture operation and constraints

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Tethered spacecraft (SC) missions are considered for the Jovian system, which suits electrodynamic-tether use because $i$) characteristic magnetic stresses are $10^2$ times greater than at Earth; $ii$) the Jovian stationary (circular, equatorial) orbit is $1/3$ the relative distance for Earth; and $iii$) moon Io, at Laplace resonance with Europa and 10 times closer to Jupiter than the Moon is to Earth, is a giant plasma source. The (bare) tether is a reinforced aluminum tape with tens-of-kilometre length $L$ and fraction-of-millimetre thickness $h$, which collects electrons as a giant Langmuir probe, allowing detailed design for both propulsion and power. This work presents the analysis of the SC capture-phase, which is critical because, once closed, orbits can substantially evolve under repeated Lorentz force. Design parameters $L$, $h$ and capture-perijove radius face opposite criteria. Efficient capture requires low perijove and high $L^{3/2}/h$ ratio. Combined bounds on tether bowing and tensile-stress (arising from a tether spin made necessary by the low Jovian gravity-gradient) require a low $L^{5/2}/h$ ratio. Keeping tape temperature within bounds require a low $L^{3/8}/(emissivity)^{1/4}$ ratio. Also, bounds on both tether temperature and bowing/tensile-stress require a high perijove. Optimal design values, and both SC mass and power generated at capture, are discussed. The case for Saturn is also considered.