

Orbiting Tether with LEO Spaceport

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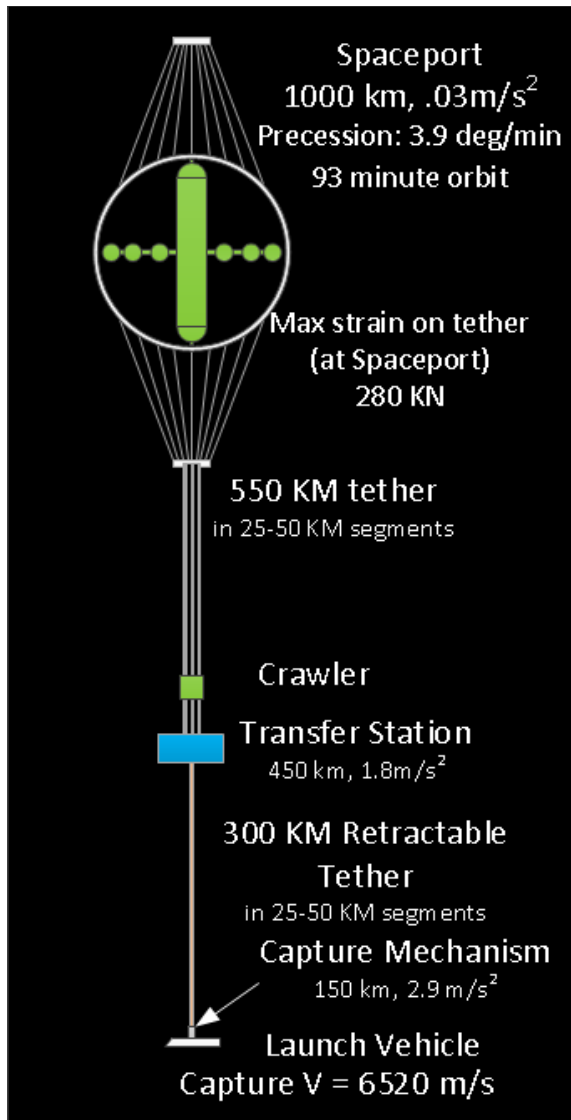
Why Orbiting Tethers

- Orbiting tethers: long tethers making one revolution per orbit, with the same end pointing down at all times
 - The tether becomes a lower energy upper stage in the launch profile – example saves >1400 m/s over orbit velocity
- Orbiting tethers provide distinct advantages over spinning tethers and non-tethered LV approaches
 - Tethers reduce final velocity to allow smaller fuel/oxidizer tanks, and lighter aero-shields for reentry
 - Tether mass is only dependent on speed savings and target mass, regardless of type (and location)
 - Orbiting tethers allow a low speed approach to the terminal, providing a much wider target box than spinning tethers
 - Equatorial LEO Orbiting tethers allow 15 launch windows/day

System Considerations

- A counter mass needed to prevent rapid orbit degradation
 - A Capture will reduce the CM by the Dry Launch Vehicle mass/System mass x tether length
 - Example: 12MT dry LV, 12,000 MT system, 850 km length = 850 meter reduction in overall CM – orbit stays nearly circular as vehicles are captured and released
 - A spaceport provides a useful counter mass
 - Limits counter mass altitude to ~1000 km to avoid Lower Van Allen Belt
 - Capture should be in near zero drag regime to avoid atmospheric dynamics during capture
 - Capture at 150 KM minimum

Orbiting Tether Concept



- Orbiting tether with Center of Mass at 993km altitude reduces velocity at 150km altitude to 6520 m/s.
- Large spaceport orbiting the Earth at 1000km altitude is a useful counter balance to a orbiting tether
- Mass
 - Captured LV = 12 MT
 - Tether = 50MT (Spectra) (2x str)
 - Transfer station = 50 MT (assumed)
 - Spaceport: 11,900 MT

Benefits

- **Increased Payload (= reduced costs)**
 - **Reduced V = Reduced Fuel = Increased Payload**
 - **Alternatively, increased structure mass allows enhanced reusability**
- **Equatorial Orbit increases launch opportunities**
 - **>14 opportunities per day**
 - **Short term travel (1 week) becomes viable**
- **Take off and landing can occur at same site**
 - **At least 1 alternate landing site needed**
- **Spaceport is a multi use facility:**
 - **modular Spacecraft assembly/test for GEO or beyond missions**
 - **Science (variable G testing)**
 - **Tourism (daily opportunities, partial G to avoid space sickness)**
 - **LEO debris clearing (small items using lasers, large items tracked more effectively)**
- **Separate tether can be used above spaceport to provide a delta V benefit to outgoing Spacecraft**

Is it Worth it \$?

- Costs - \$30 Billion (Mostly for Spaceport)
 - \$15 B Launch costs (225 FH launches at ~\$67M each)
 - \$15 B Development/Construction
- Return - \$5 Billion/year
 - \$2B/year tourism (daily flights)
 - \$2B/year Science
 - \$1B/year Industry including:
 - Pharmaceuticals
 - Materials
 - Spacecraft Assembly and Test
 - IRR >12% (~10% @ \$40B cost, ~8% @ \$50B)

Path to testing

- Equatorial orbit not needed for (unmanned) test system
 - <2000 kg system can be used to capture 200 kg test loads, with a 200km multi-segment tether for accurate test, any orbit
 - Capture V is >300 m/s below orbital speed for this shorter tether
 - Mass portion dedicated to tether/capture/retraction is <700 kg, balance available for other missions
 - Use of Aircraft 1st stage for test load launch allows frequent (1/week) opportunities to test/validate concept