Cost-Effective End-of-Mission Disposal of LEO Microsatellites: The Terminator Tape

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**Objective:**
- Meet 25-year lifetime restriction with bare minimum of mass, unit cost, integration complexity, & technical risk

**Solution:**
- At spacecraft end-of-life, deploy a conducting tape structure from spacecraft
- Deployment initiated by pyro signal from host spacecraft
- Gravity gradient forces align tape along local vertical
- Tape dramatically increases aerodynamic drag area of spacecraft
- Conducting tape also generates **passive** electrodynamically drag through interactions with Earth’s magnetic field and ionospheric plasma
Passive Electrodynamic Drag

- Passive electrodynamic drag observed as far back as the Echo balloon experiments.
- Gravity gradient orients tape structure along local vertical.
- Works regardless of whether its deployed in nadir or zenith direction.
Terminator Tape for ESPA Microsats

- Sized for ESPA-class microsatellites
  - ≤ 180 kg spacecraft
  - ≤ 900 km

- ‘Flat Box’ form factor:
  - 20.3 x 20.3 x 3.8 cm (8”x8”x1.5”)
  - ≤ 1.5kg

- 2 Non-Explosive Actuators
  - Inhibit
  - Deployment actuation

- Deploys a 50 m x 0.5 m conducting tape
  - Baseline tape materials have flight heritage, no outgassing concerns

- Fits within ESPA LightBand
Mechanism Prototype

1.5”

8”

8”
De-orbit Time

180 kg Spacecraft

Variation due to solar cycle
• Area-Time-Product determines probability of a collision during satellite’s lifetime

Despite its deployed size, Terminator Tape roughly halves the satellite’s Area-Time-Product

Most of that Area-Time-Product is gossamer thin film
  • Much lower chance of catastrophic debris generation if tape impacts another space object
    • Less energy/area than a firecracker, even at 14 km/s relative velocity
Microgravity Deployment Testing

Deployment Successfully Demonstrated In Microgravity
CubeSat Terminator Tape

- Enables CubeSats to meet 25-year post-mission lifetime requirements at up to 1000 km altitude
- Can use TUI’s Nanosat Release Mechanism for activation
  - Activated by signal from host or deadman timer for DOA cubesats
- Pass-throughs for surface-mounted solar cells
- Estimated Volume: 100x83x5 mm
- Estimated Mass: < 80 g

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Summary

- Terminator Tape designed to enable microsats to comply with 25-year orbit lifetime restriction with minimum mass, cost, and risk impact
- Deployment of prototype validated in microgravity
- Technology is readily scalable
  - Prototypes developed for ESPA microsats & CubeSats