

IAC-04-S.P.07

The Spinning Electrodynamic Thruster (SET): An Order of Magnitude Improvement over Ion Thrusters

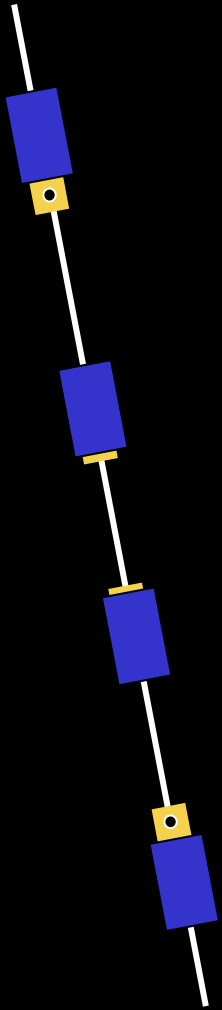
55th International Astronautical Congress
Vancouver, Canada, October 4-8, 2004

Jerome Pearson & Eugene Levin, STAR, Inc., USA

jp@star-tech-inc.com; elevin@mn.rr.com

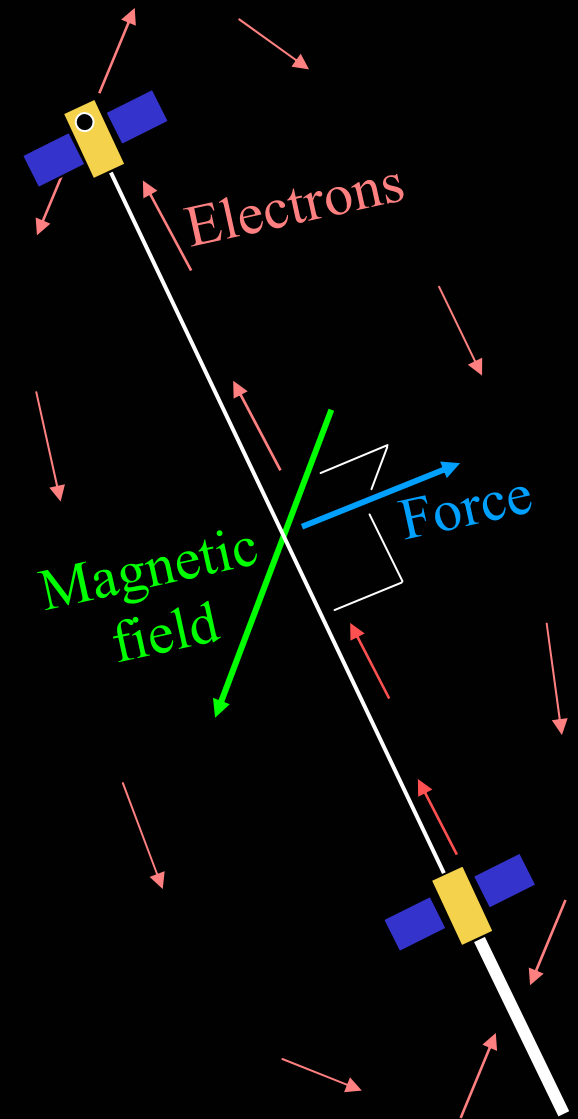
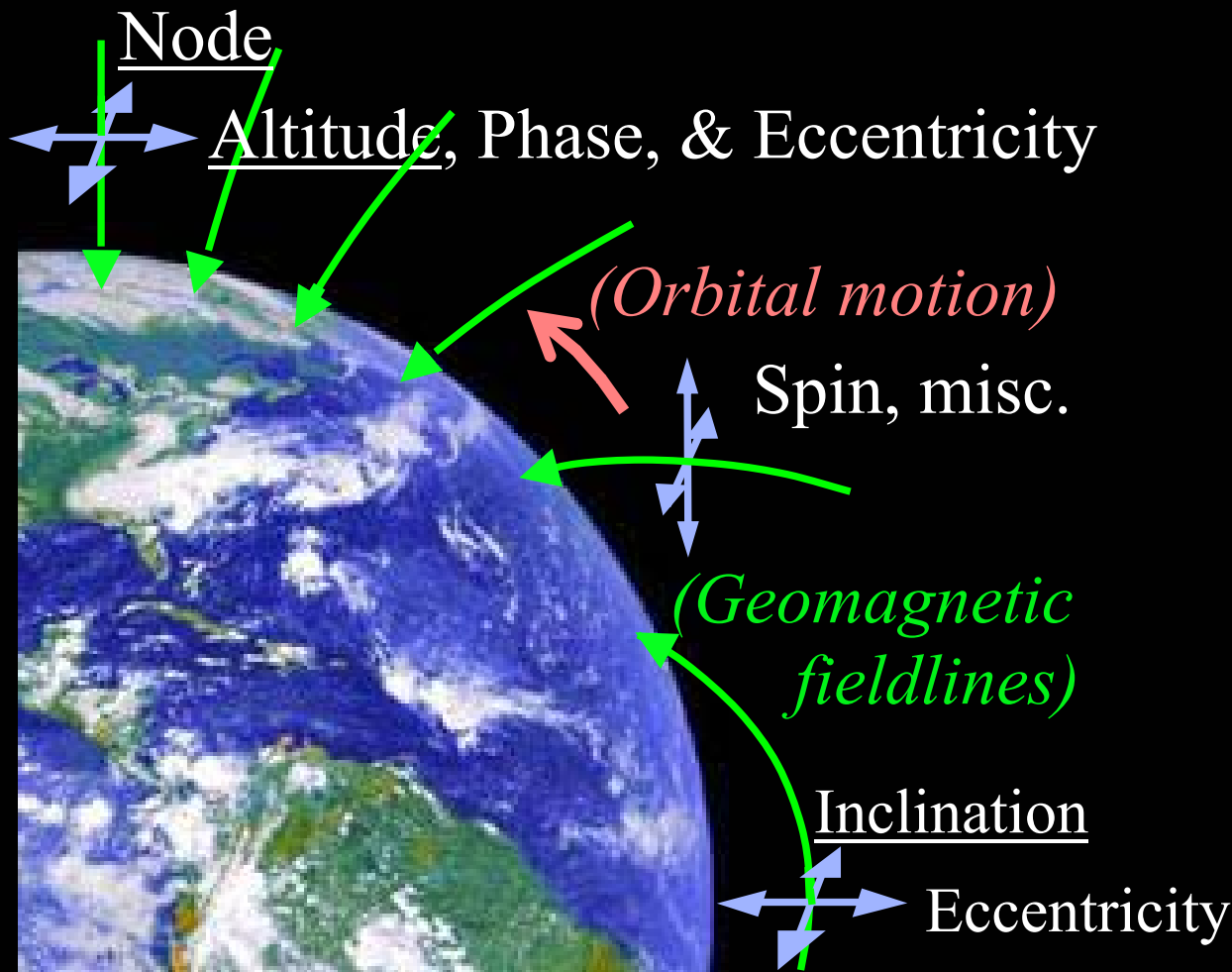
Joseph Carroll, TAI, USA; tether@cox.net

John Oldson, STAR, Inc./ESLI, USA; joldson@esli.com



Electrodynamic Orbit Changes

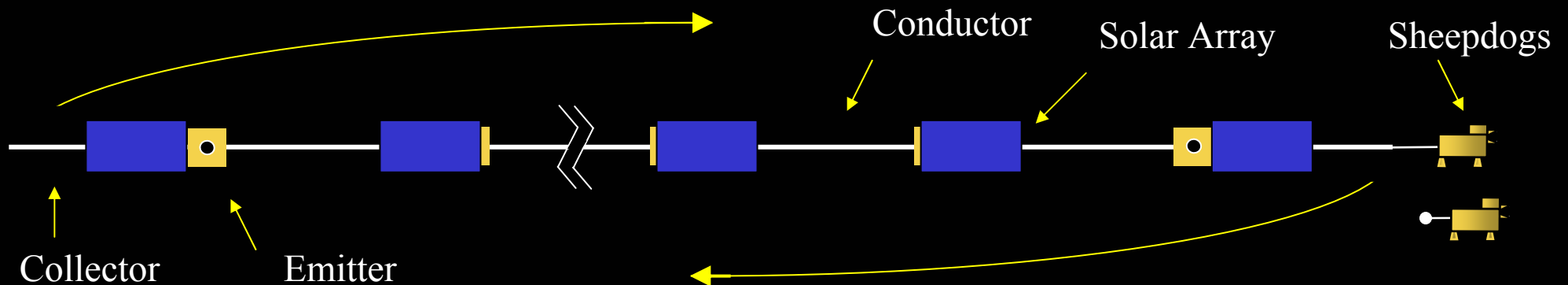
Elements changed by ED force:



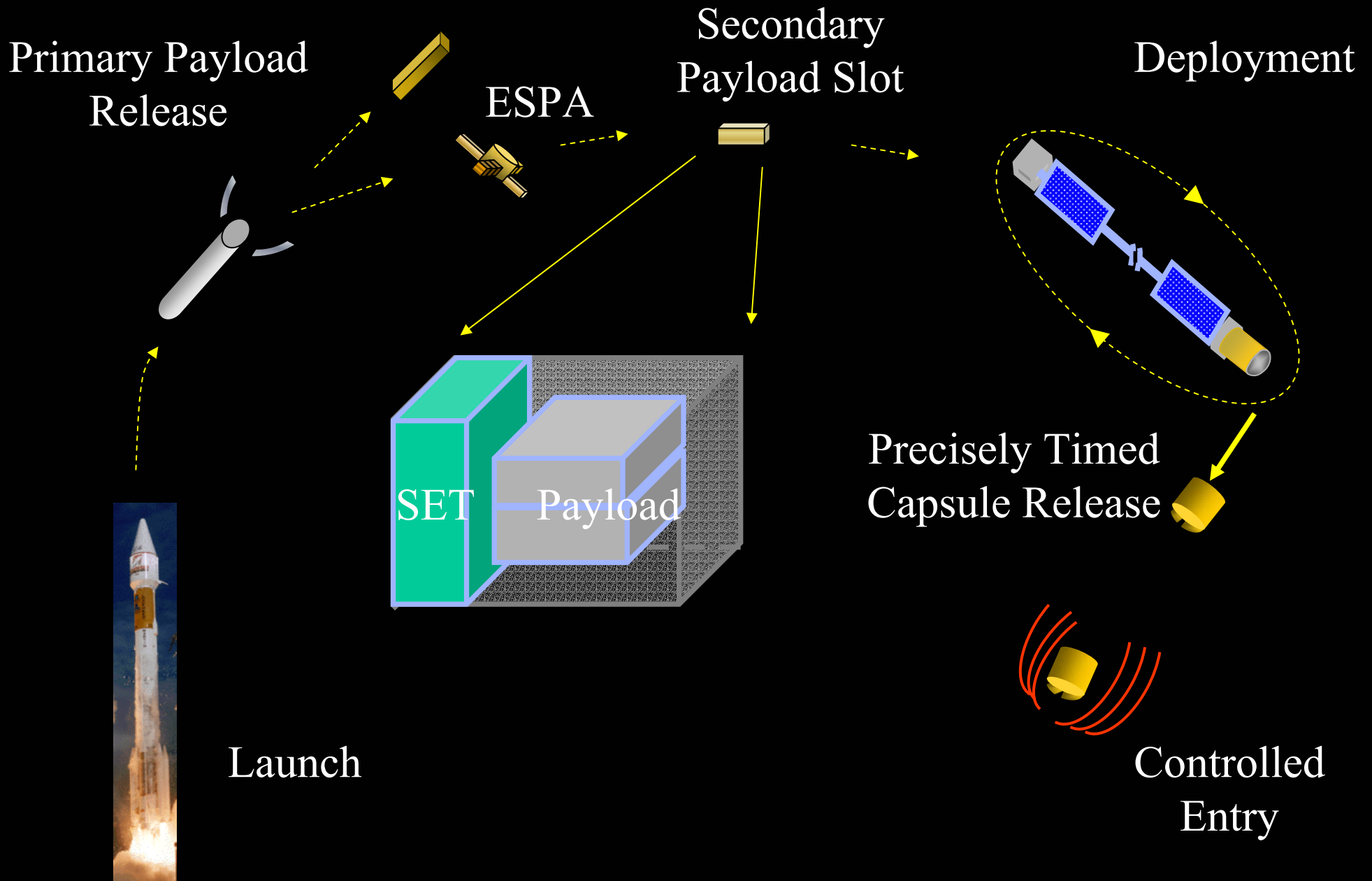
Spinning at about 6 revs/orbit allows force direction control

System Design

1. **Always-spinning mode** (passive brake; flexible ops)
2. **Direct-drive solar arrays w/o batteries**: lowest mass
3. **Multi-stage design** prevents arcing failure; robust
4. **All-bare tether** allows maximum service altitude
5. **Paired “sheepdogs”** allow inspection & repair, etc.
6. **Agility + stamina** let each SET serve many roles



Secondary Payload Launch

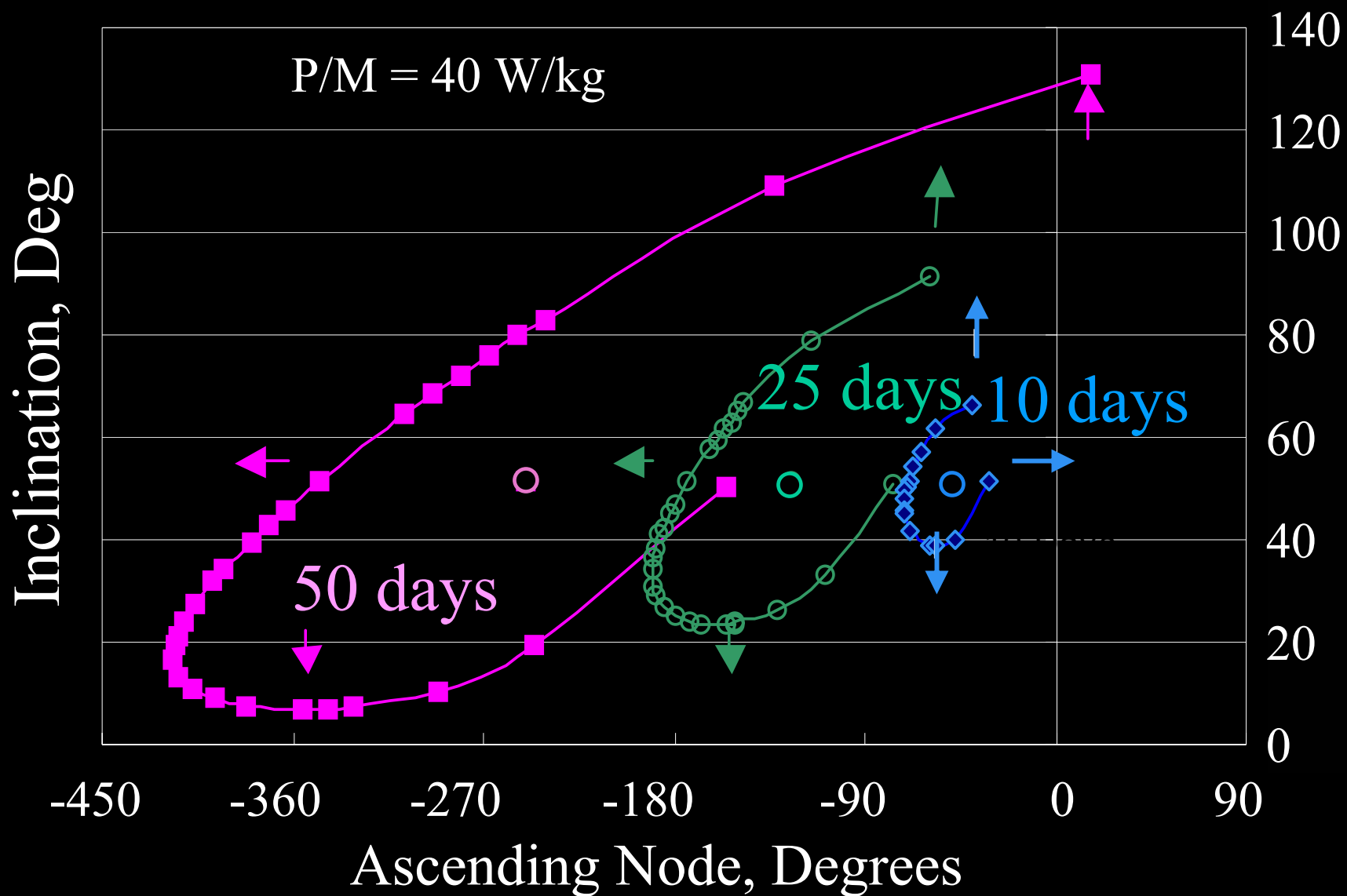


Comparison With Other Thrusters

System	Fluid kg	Dry kg	Thrust mN	SpPwr kW/N	Isp sec	Runtime months	Ns/kg (total)
NH ₃ Arcjet	500	200	2000	13	800	1	6K
SPT-100	72	25	78	17	1600	8	12K
DS-1 Ion	82	253	92	27	3100	14	7K
10kW Hall	400	250	450	22	3000	13	18K
Mini SET	4	21	20	50	-	24	19K
SET	15	85	500	20	-	60	295K

Effective thrust for typical orbit changes, thrusting only in sun (75% of time in LEO). Dry mass includes solar array and PPU; fluid includes neutralizer.

Orbit Transfer From ISS



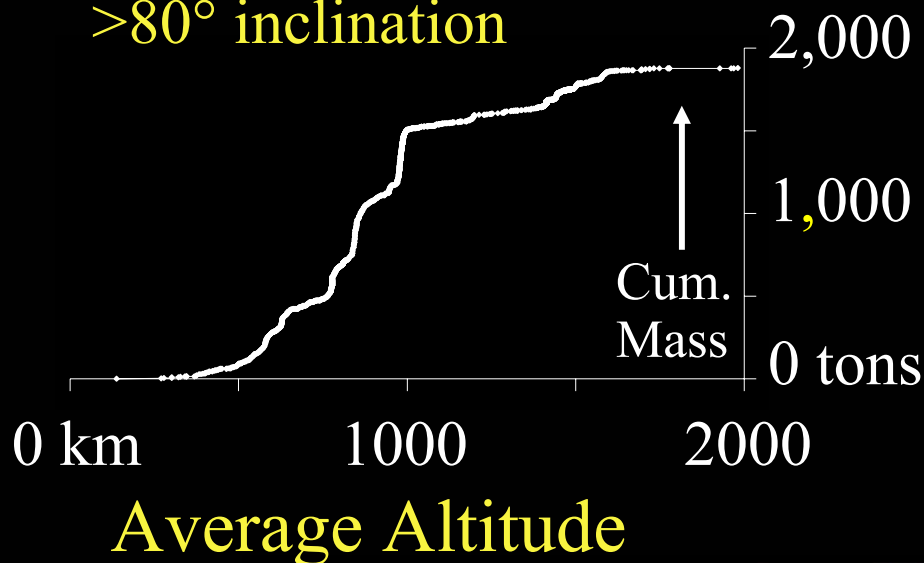
Operational Capabilities

- High-delta-V orbit transfers (2008 launch):
 - ISS to 900 km orbit, 80-kg payload, 1 day
 - ISS to polar orbit, 80-kg payload, 18 days
 - ISS to equatorial orbit, 80-kg payload, 49 days
 - GTO to 600-km LEO, 52-kg payload, 60 days
- Operational envelope includes circular orbits up to 2000 km, and elliptical orbits beyond GEO
- Controlled artificial gravity, micro-g to 1 g
- Autonomous, minimum-time orbit transfers

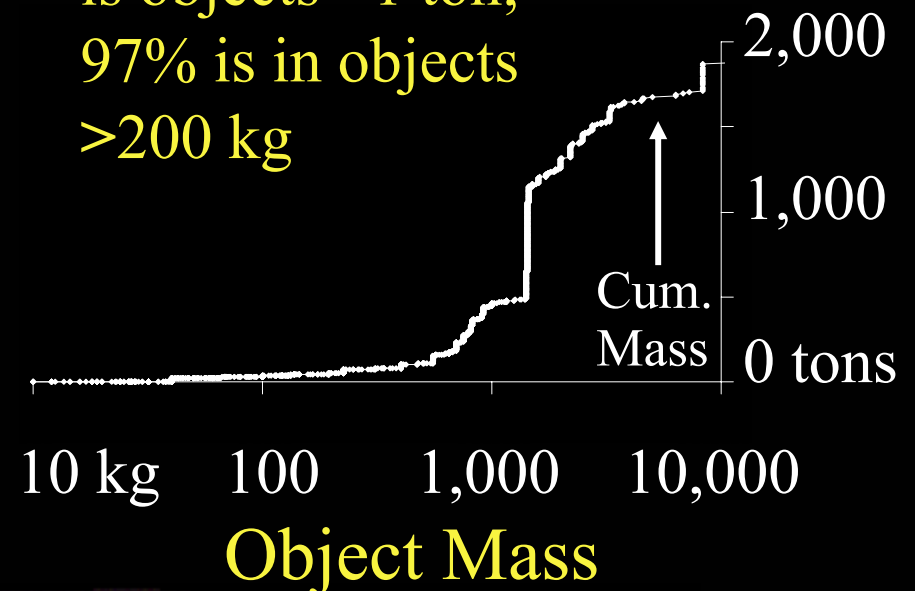
Applications

- Affordable debris and dead satellite removal
- Cheap, high- ΔV upper stage and orbit transfer
- Artificial gravity and precise atmospheric entry
- Satellite inspection for space exposure effects

Most debris is at
500-1000 km,
>80° inclination



75% of the debris
is objects >1 ton;
97% is in objects
>200 kg



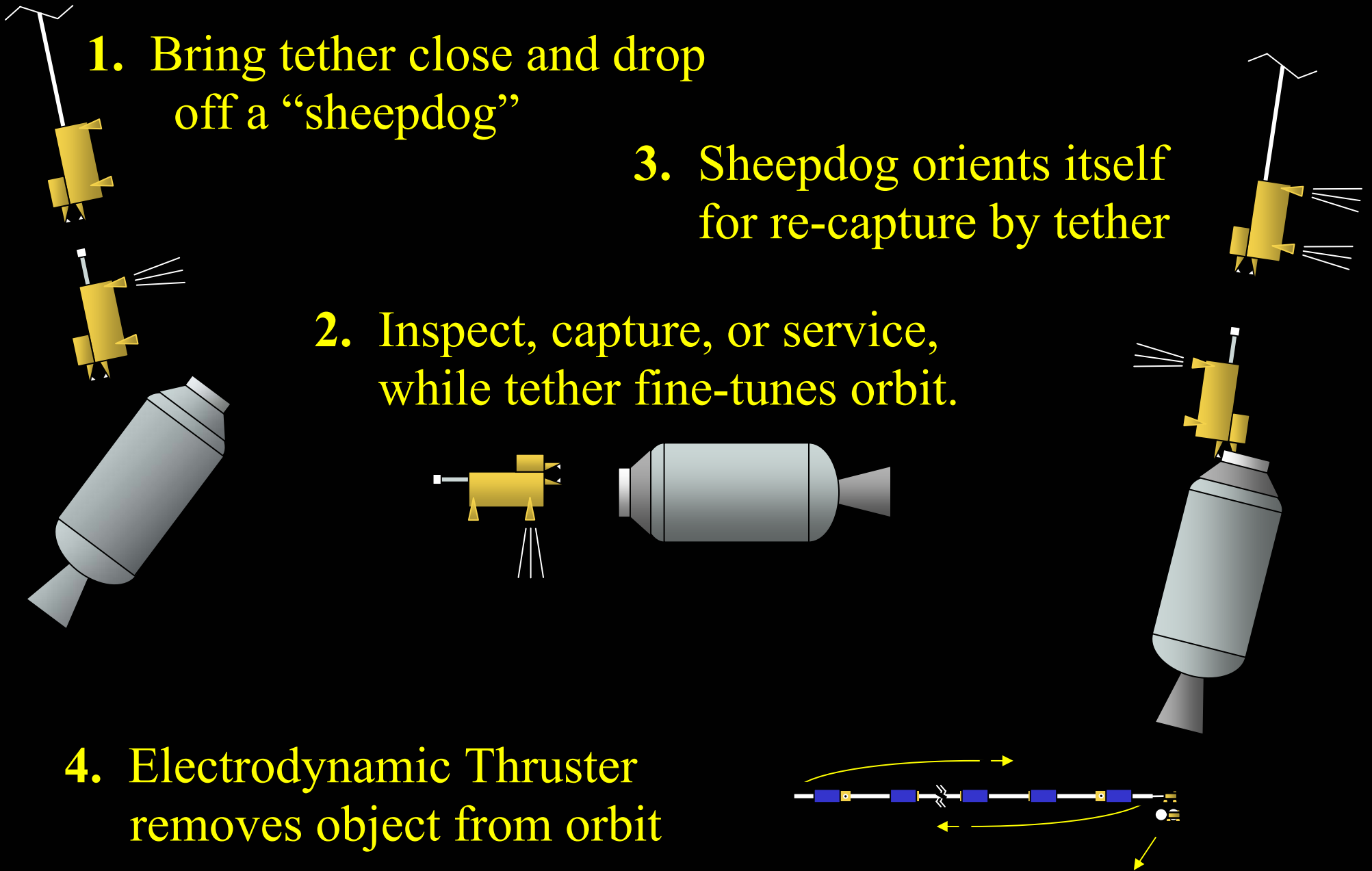
Inspect, Service or Remove Objects

1. Bring tether close and drop off a “sheepdog”

3. Sheepdog orients itself for re-capture by tether

2. Inspect, capture, or service, while tether fine-tunes orbit.

4. Electrodynamical Thruster removes object from orbit



Conclusions

- The Spinning Electrodynamic Thruster (SET) provides new on-orbit propulsion capability
- SET provides an order of magnitude higher delta-V than ion thrusters
- SET enables revolutionary new missions
- SET is low cost and lightweight
- SET is compact—can be launched with 80 kg of payloads in an EELV secondary slot