CubeSat-Class Spinning Landers for Solar System Exploration Missions

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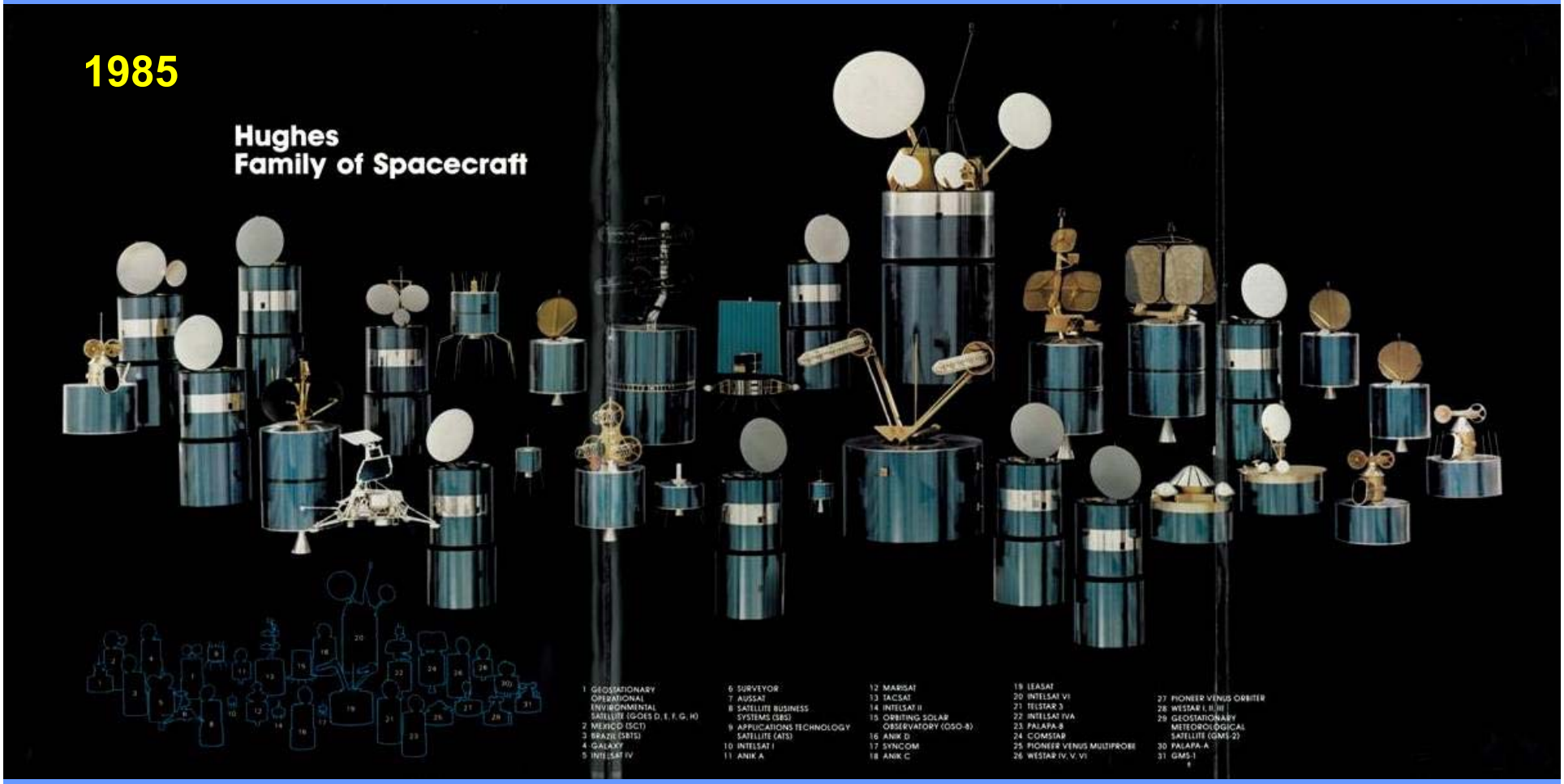
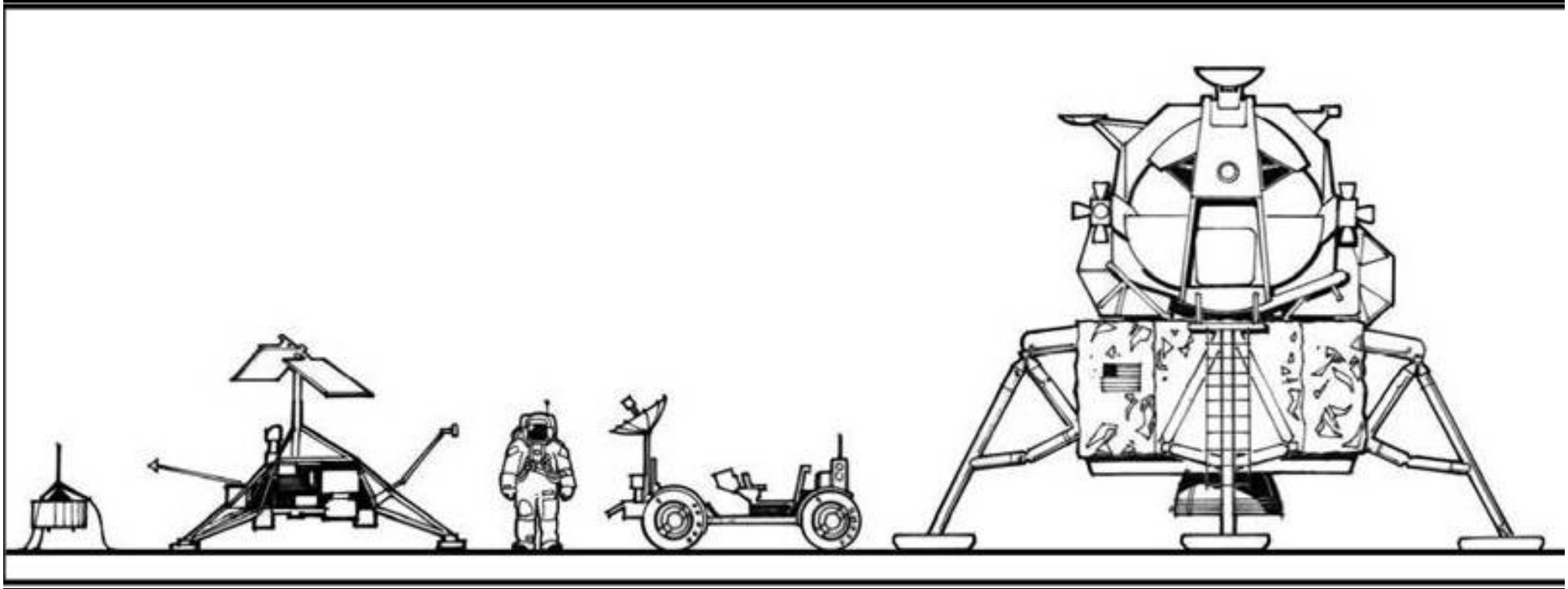
San Luis Obispo, CA
2014 Apr 25

Scalable Spinning Satellites

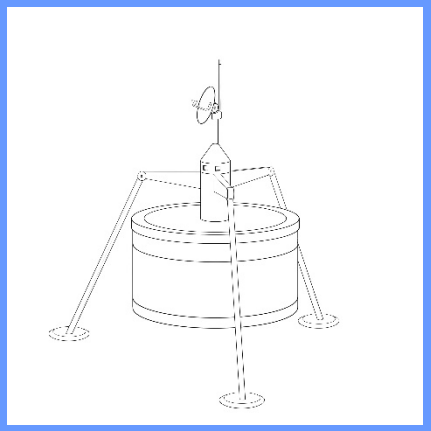



Google
LUNAR XPRIZE
2008
OFFICIAL TEAM
SCSG
SOUTHERN CALIFORNIA SELENE GROUP

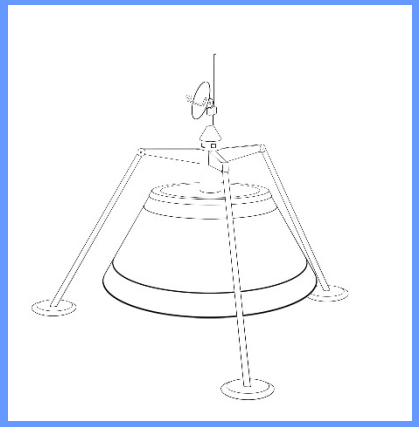
Size Comparison for GLXP Win



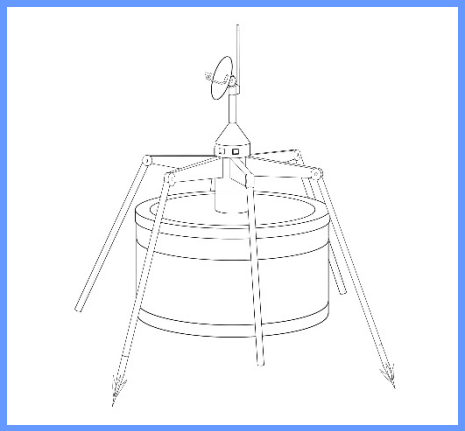
Notional Lander Concepts*



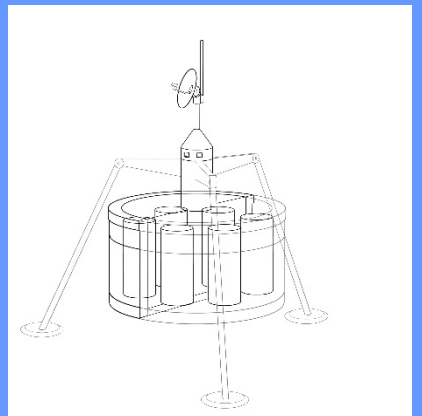
Lunar



Mars



Asteroid



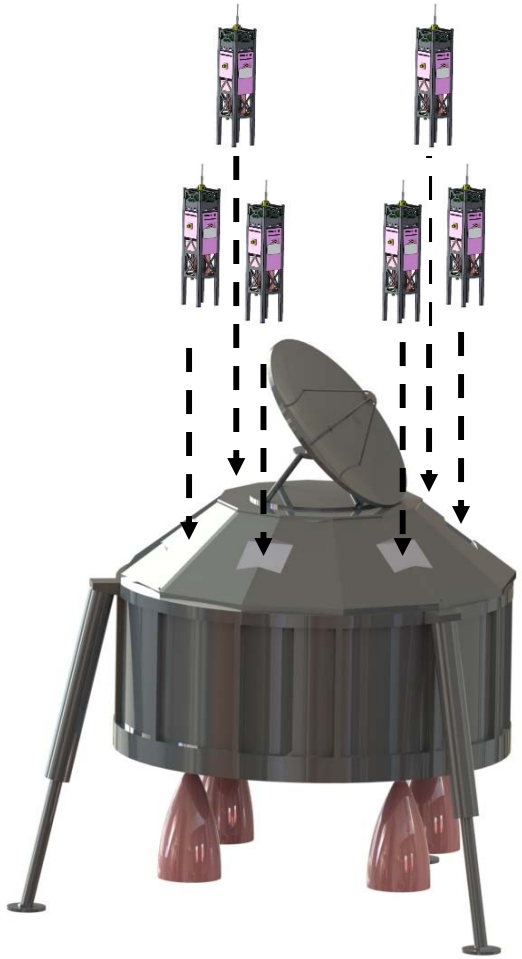
Commercial

* First presented at 2011 Low-Cost Planetary Missions Conference (APL/Laurel, MD)

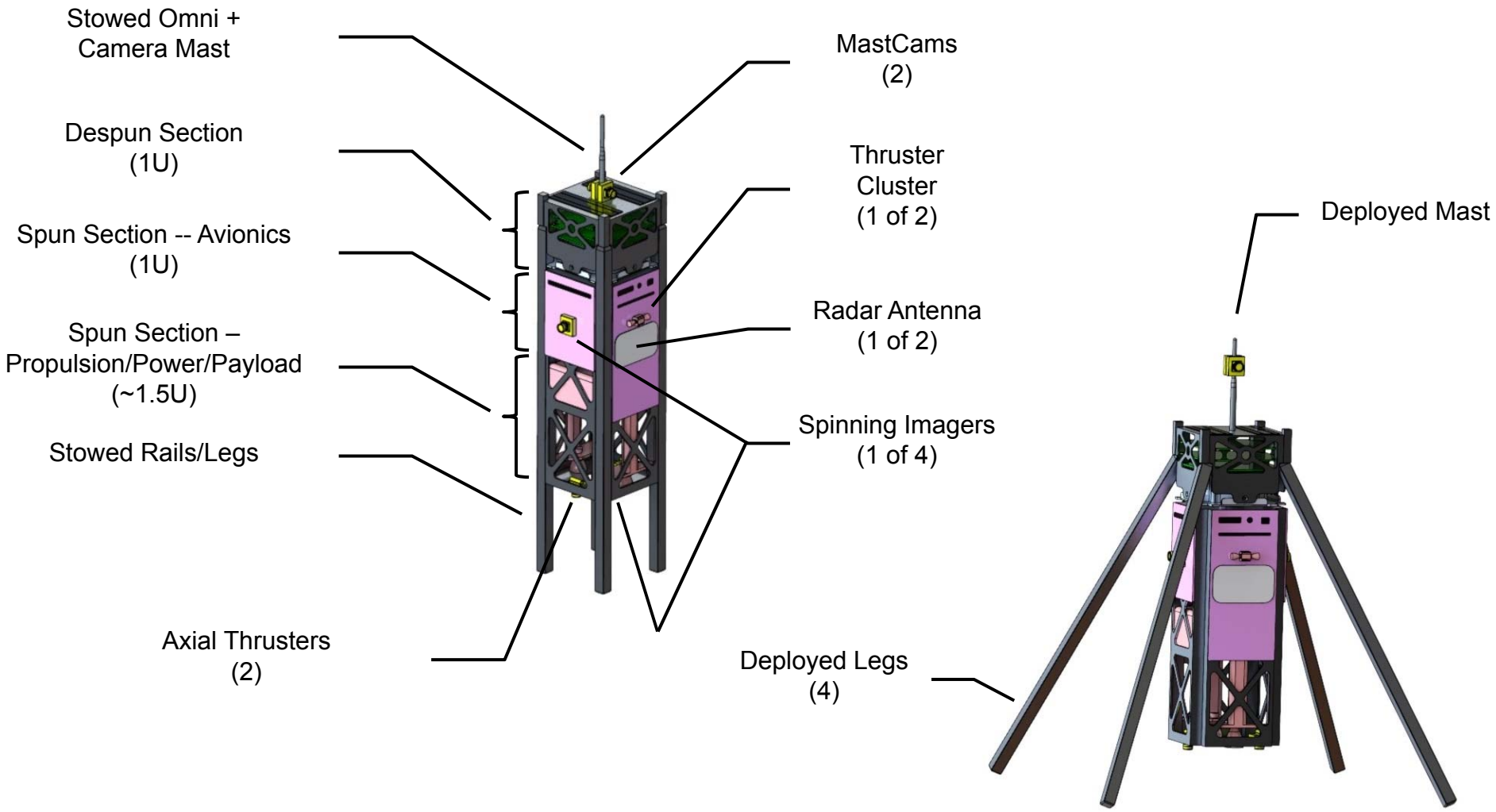
Notional CubeSat-Class Lunar Mission

- **Objective**
  - Explore lunar polar craters
- **Mission architecture**
  - Multiple piggyback spinning landers on larger lander
  - Mobility (hopping) within ~1 km radius of main lander
  - Various remote-sensing and in-situ science goals
- **Spinning lander attributes**
  - ~3.5U dual-spin CubeSats with legs
  - Spun-despun interface based on MIT design
  - Legs derived from stowed CubeSat rails
  - Nominally battery-powered; solar optional
  - TBD propulsion (various options)
  - Wireless comm to/from main lander during all mission phases
  - Variable science instrument complements
  - Multiple webcam-like imagers

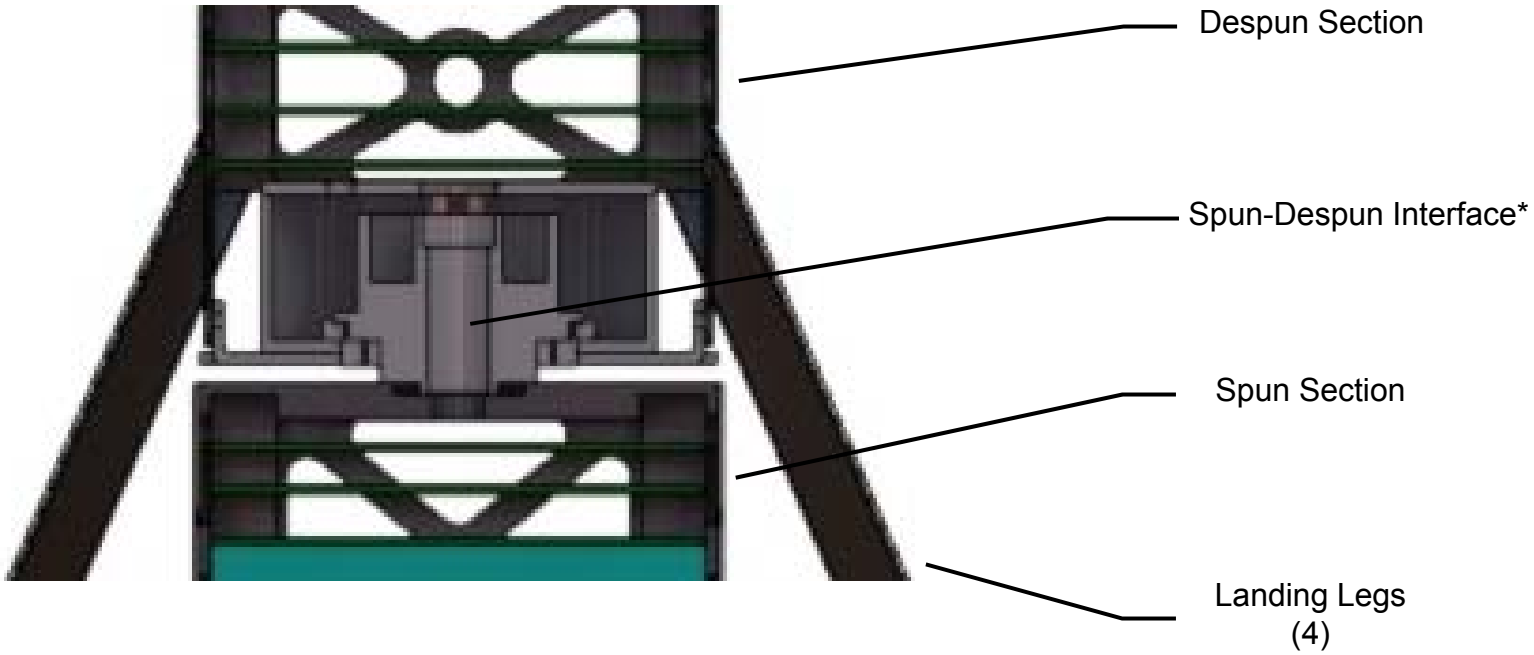
Main Lander and Stowed Spinning Landers



Spinning CubeSat-Class Lander

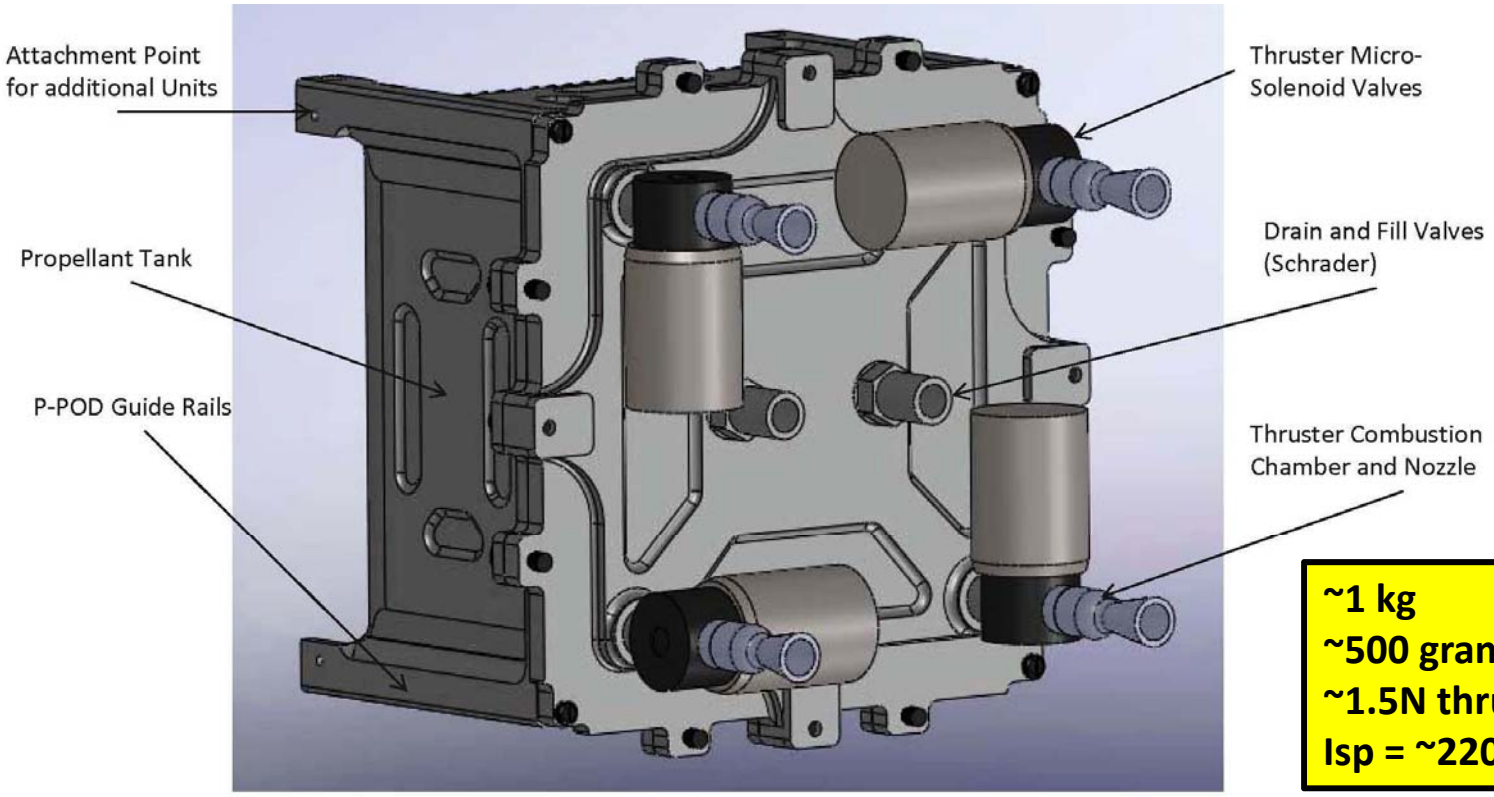


Spun-Despun Interface



See: Eric Peters, et al., MIT Space Systems Lab: *Design and Functional Validation of a Mechanism for Dual-Spinning CubeSats*, Paper SSC13-WK-08, CubeSat Workshop at Annual SmallSat Conf., Logan, UT, 2013 Aug 10

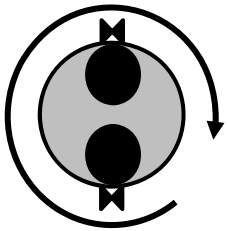
Sample Prop Module



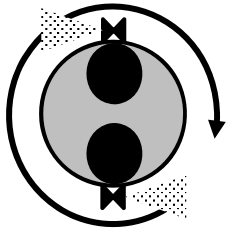
~1 kg
~500 grams propellant
~1.5N thrusters
Isp = ~220 sec

See: Chris Biddy and Tomas Svitek, Stellar Exploration, Inc.: *Monopropellant Micropropulsion System for CubeSats*, Paper SSC09-II-2, at Annual SmallSat Conf., Logan, UT, 2009 Aug

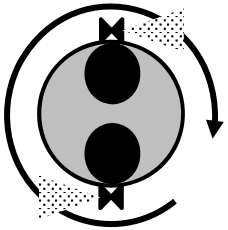
Maneuvering



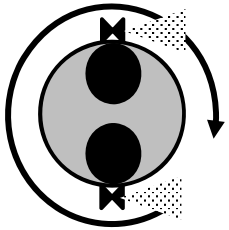
Bottom View



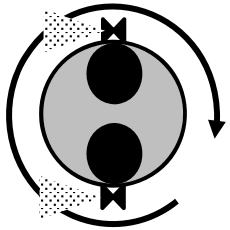
Spin Up
(Continuous)



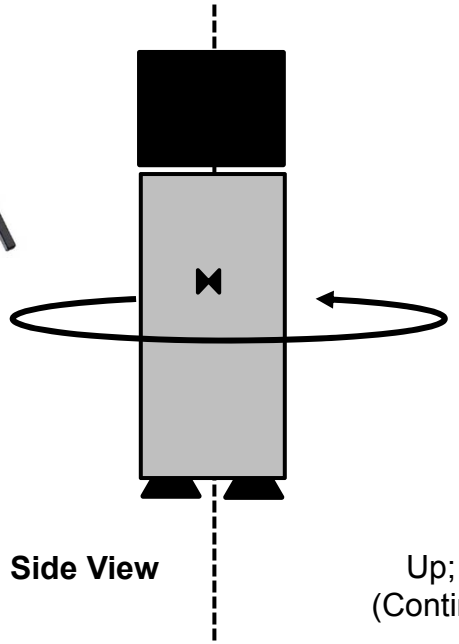
Spin Down
(Continuous)



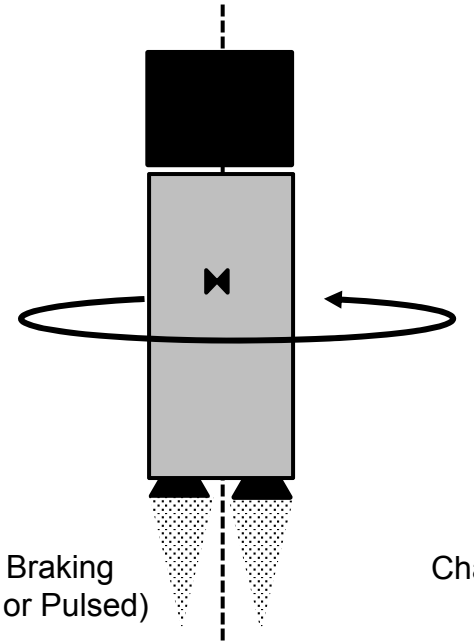
Move Left
(Pulsed)



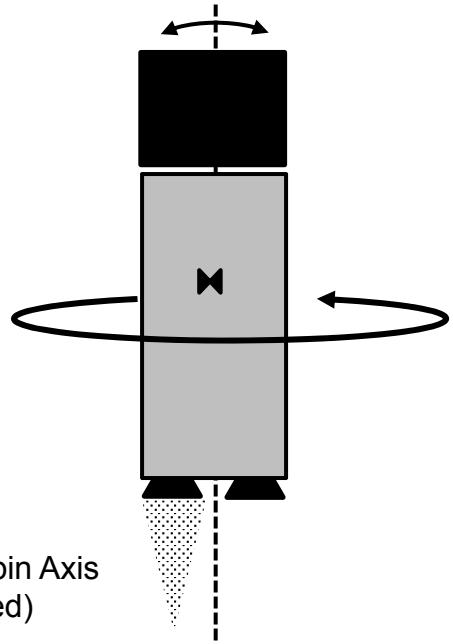
Move Right
(Pulsed)



Side View

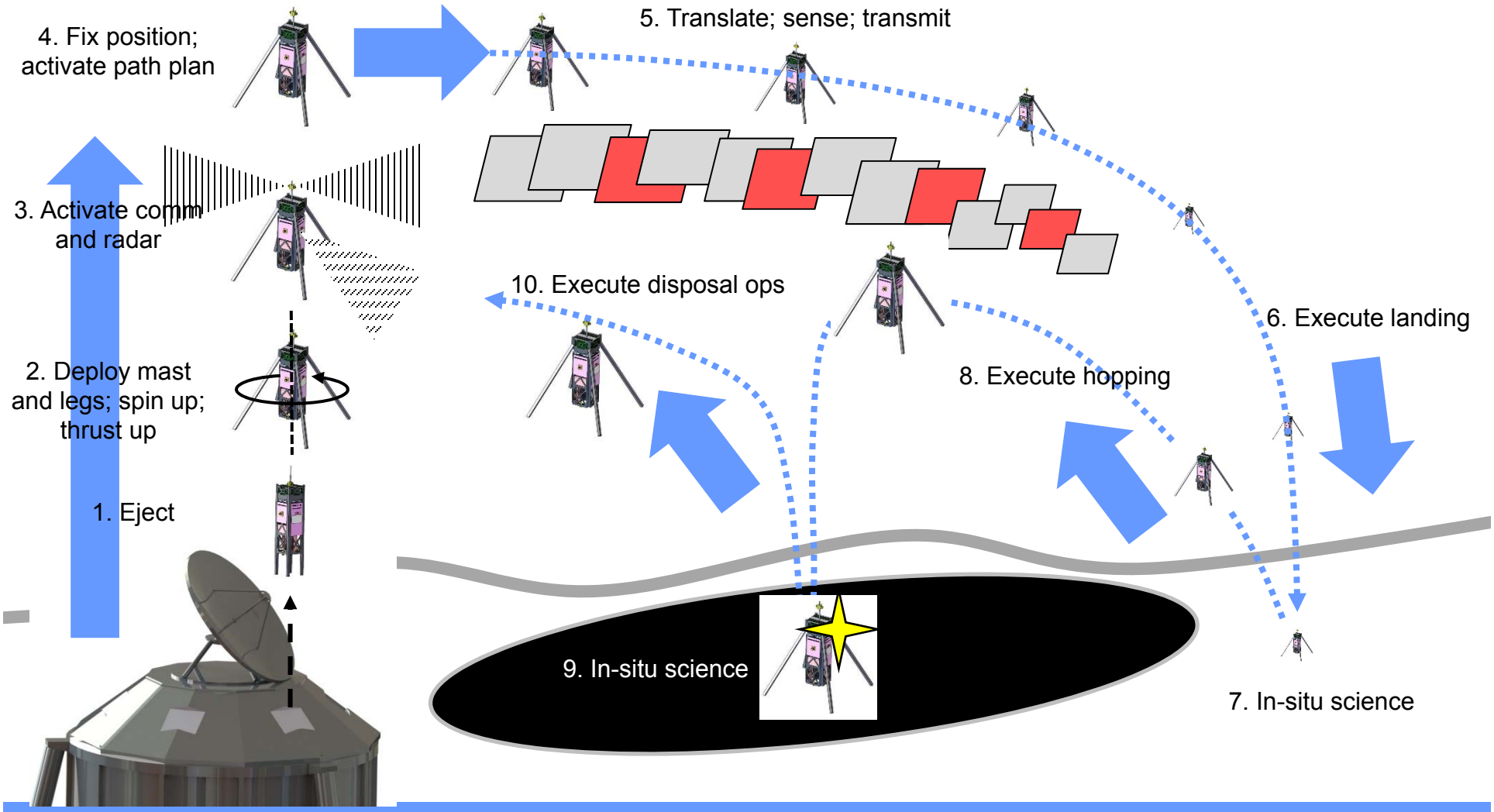


Up; Down Braking
(Continuous or Pulsed)

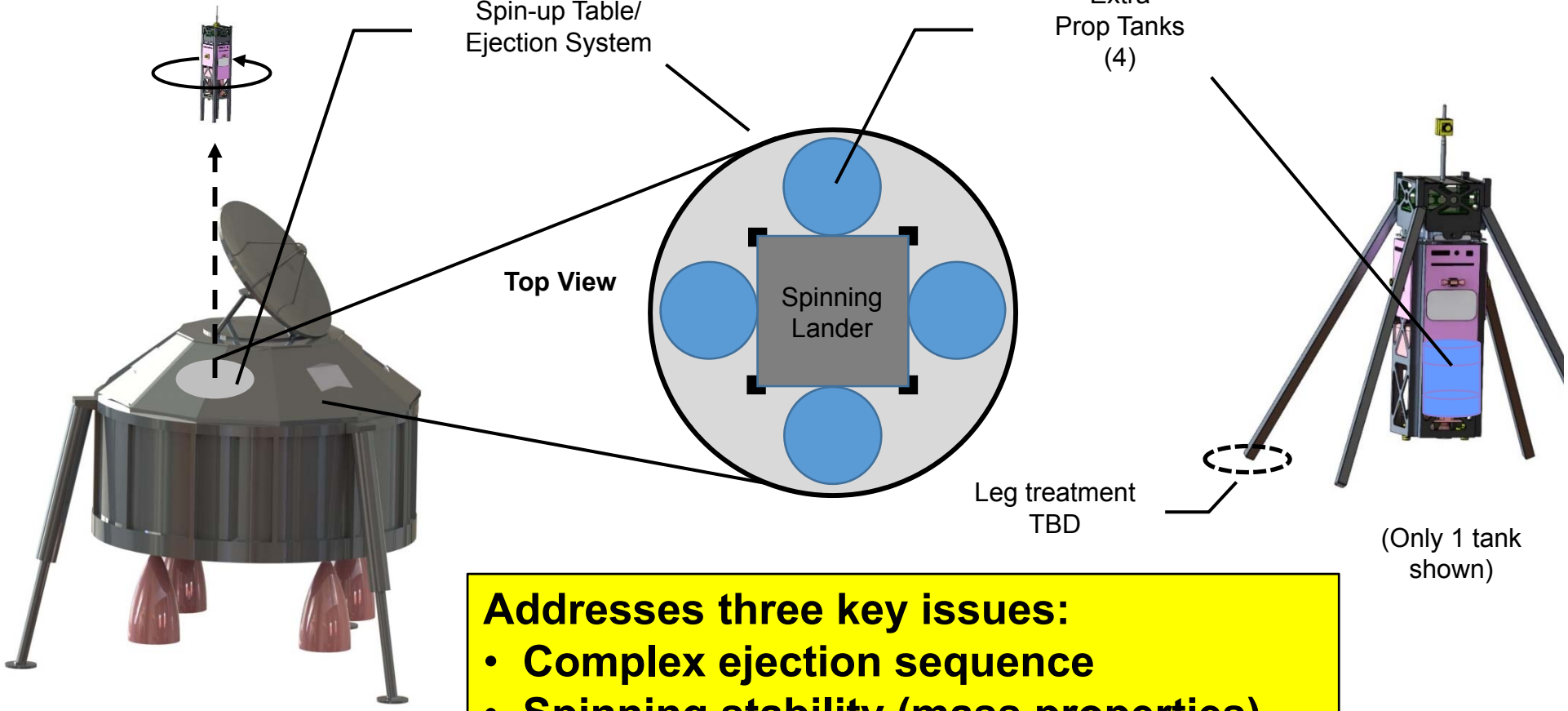


Change Spin Axis
(Pulsed)

Typical CONOPS



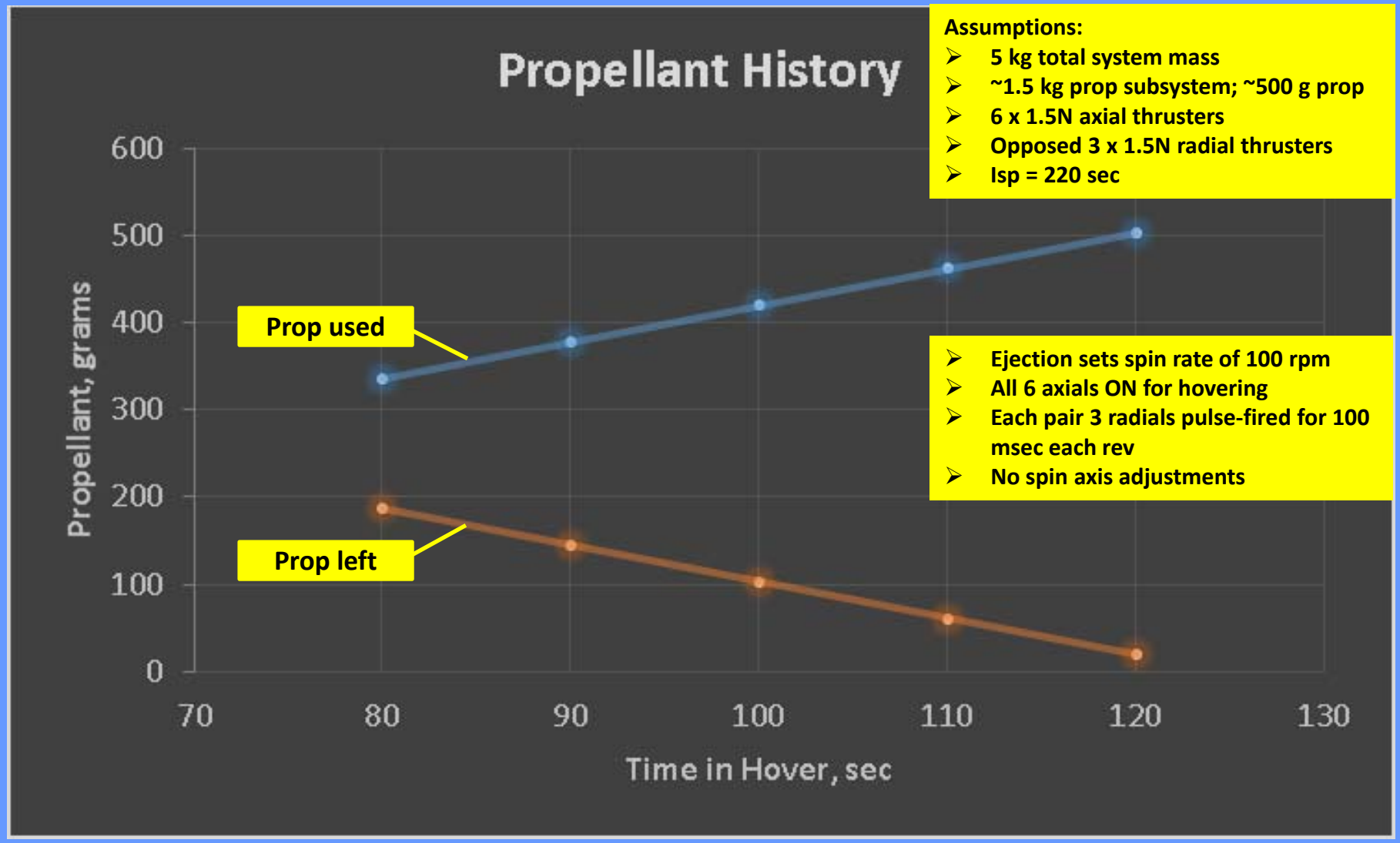
v. 2.0?



Addresses three key issues:

- **Complex ejection sequence**
- **Spinning stability (mass properties)**
- **Propulsion and ΔV capability**

Rough Performance -- Hovering

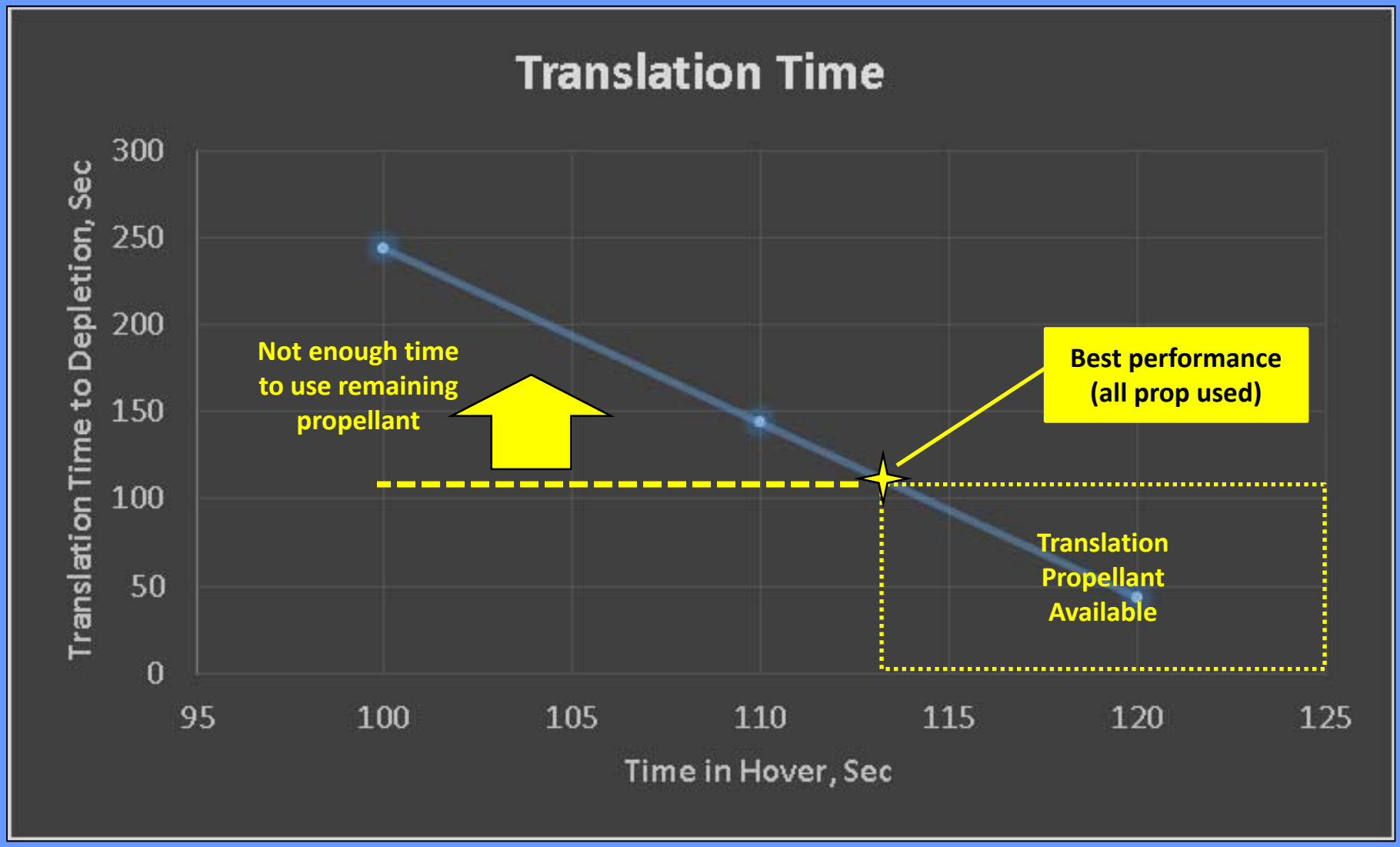


Assumptions:

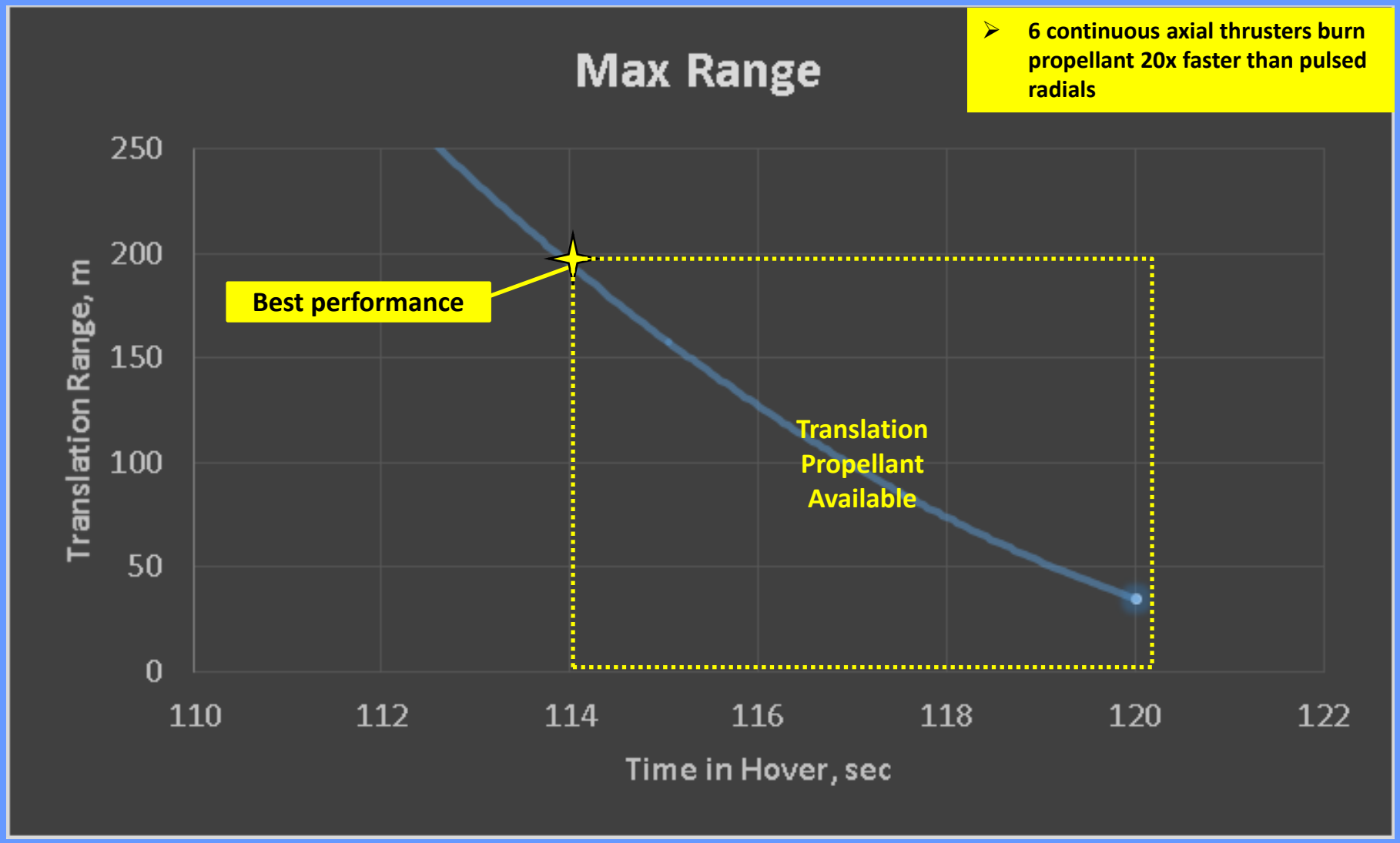
- 5 kg total system mass
- ~1.5 kg prop subsystem; ~500 g prop
- 6 x 1.5N axial thrusters
- Opposed 3 x 1.5N radial thrusters
- Isp = 220 sec

- Ejection sets spin rate of 100 rpm
- All 6 axials ON for hovering
- Each pair 3 radials pulse-fired for 100 msec each rev
- No spin axis adjustments

Rough Performance -- Translation



Rough Performance -- Range



What's Next?

- **Discuss and assess mission concepts**
  - And notional science instruments, CONOPS, etc.
- **Assess subsystem requirements**
  - Esp. GN&C, ADCS, propulsion
- **Assess technology readiness and gaps**
  - Esp. propulsion, landing radar
- **Assess integration issues**
  - Spinning lander itself and with main lander
- **Simulations, mission animations, concept art**

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