A High-Power Articulated Solar Array for Lunar 6U CubeSats (DASA)

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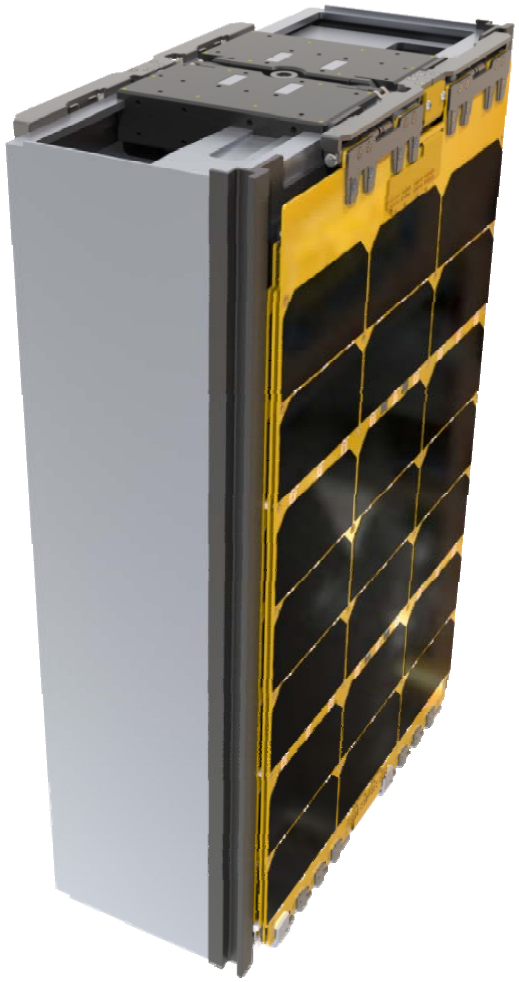
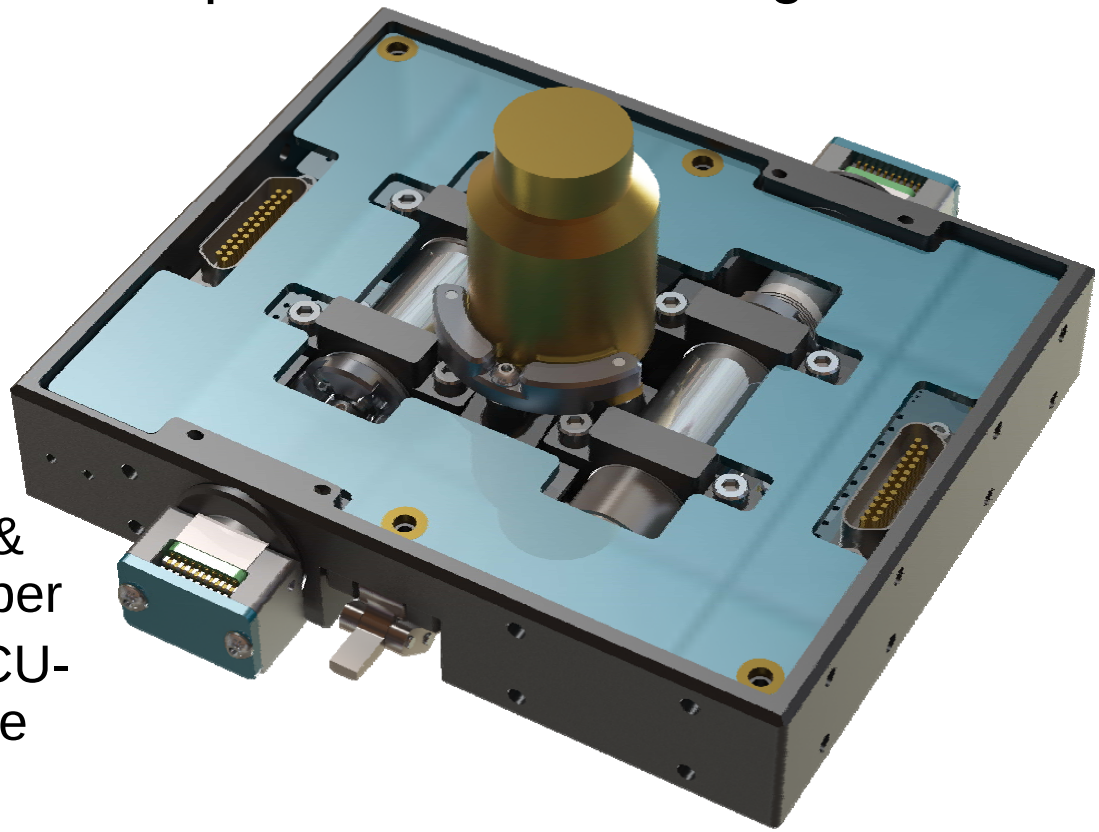
L-IC Requirements

- Lunar mission
- > 100W array
- Stowed as CSD-compatible 6U
- Articulated about 1 axis
- Part of a power system for Hall thruster
- Compatibility with L-IC's own 6U chassis
- Use GSFC-approved stepper motors and H-bridge drive
- Use NASA-approved 18650 cells



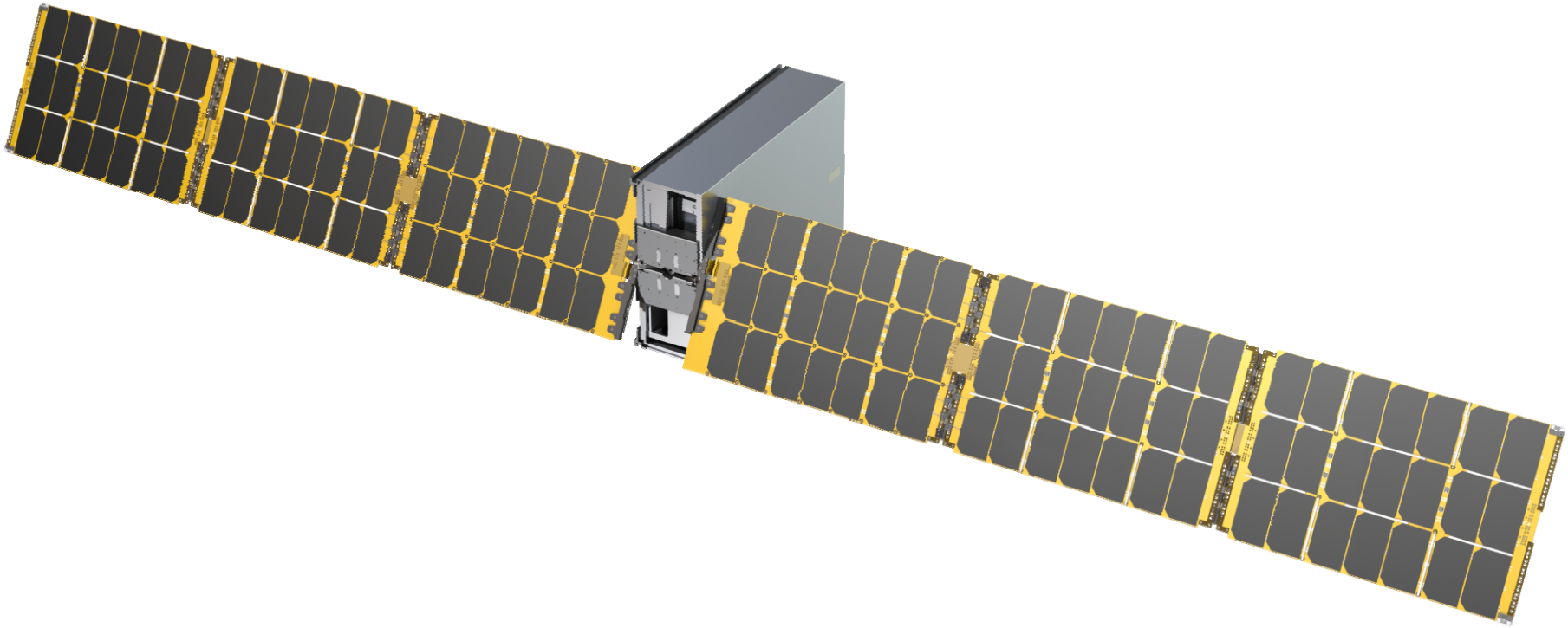
Motor Block

- Faulhaber 15mm stepper motors + reduction gearbox
- Discrete 12V H-bridge driver with JANS-class components
- Based on motor spec, developed dual-motor design with extreme symmetry:
  - Isolation in 3 axes
  - +/-200 degree rotation
  - Flex interconnects
  - 3 independent strings
  - 4 sensors
  - TiNi PP-based release
  - Independent controller & telemetry for each stepper
  - Direct-drive and SupMCU-based commanded drive



Solar Panels

- 5th-gen PMDSAS (TRL 9) technology
  - Similar to SUPERNOVA 24-cell panels
  - 3 x 21S per side, for a total of ca. 126W BOL per DASA
  - Temperature sensor on each panel
  - Patented “no stress” electromechanical resettable release mechanism



Power System Issues

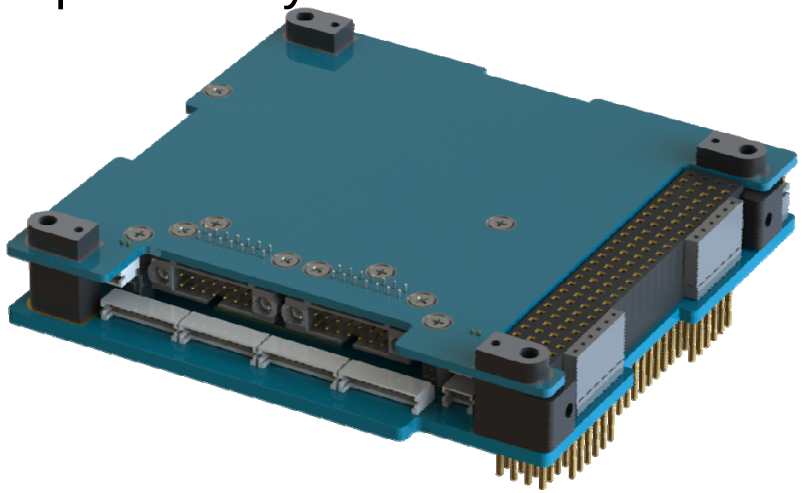
- 6x 21S (nom. 6 x 55V @ 400mA) presents some challenges:
  - A single string's voltage exceeds typical CubeSat EPS ratings
  - A single string's power exceeds typical CubeSat EPS ratings
  - 126W greatly exceeds most battery system's Wh rating

- 6x 21S presents some advantages:
  - By not paralleling at the array, we don't lose everything if a string fails
  - The impact of blocking diode losses is minimized
  - Fewer signal paths, at lower currents

- Impact of NASA-approved Panasonic 18650 cells:
  - Not all that common in CubeSats
  - Very high energy
  - Unexciting CHG and DSG rates

Power System Solution

- Incorporate a more capable battery with:
  - Much greater energy (100Wh) than typical
  - Much greater power (80/160W) than typical
  - SoC telemetry, cell balancing, auto-recover-from-faults, etc.
- Incorporate a multi-channel, high-efficiency EPS with:
  - 60V @ < 1A in per input channel
  - 97% min efficiency (GaN-based)
  - Ability to charge batteries at up to 8A per battery



DASA Advantages

- Dual-motor, supersymmetric design
- No slip rings or discrete cabling in solar panels power path
- Ultra-high-rel, *testable*, pin puller release mechanism
- Rad-hard H-bridge driver with discrete control inputs
- SupMCU-based telemetry & control that parallels the H-bridge driver
- 125W+ power in a 6U-compatible form factor
- Easy tie-in to Pumpkin BM 2 (high-energy, high-power intelligent battery module) and Pumpkin EPSM 1 (high-power, high-efficiency multi-channel programmable EPS)
- Combines TRL 9 components with ground-tested advancements in CubeSat technology

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SPACE SYSTEMS

Q&A Session

Appendix

- **Acknowledgements**
  - Dr. Ben Malphrus and his team at Morehead State University, for the partnership in developing and fielding DASA.
- **Speaker information**
  - Dr. Kalman is Pumpkin's president and chief technology architect. He entered the embedded programming world in the mid-1980's. After co-founding Euphonix, Inc – the pioneering Silicon Valley high-tech pro-audio company – he founded Pumpkin, Inc. to explore the feasibility of applying high-level programming paradigms to severely memory-constrained embedded architectures. He is the creator of the Salvo RTOS, the CubeSat Kit and the SUPERNOVA architecture. He holds several United States patents. He was a associate professor in the Department of Aeronautics & Astronautics at Stanford University and directed the department's Space Systems Development Laboratory (SSDL) 2008-2017. Contact Andrew at aek@pumpkininc.com.
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