ARKSAT-1, 1U CUBESATELLITE DEVELOPED AT THE UNIVERSITY OF ARKANSAS

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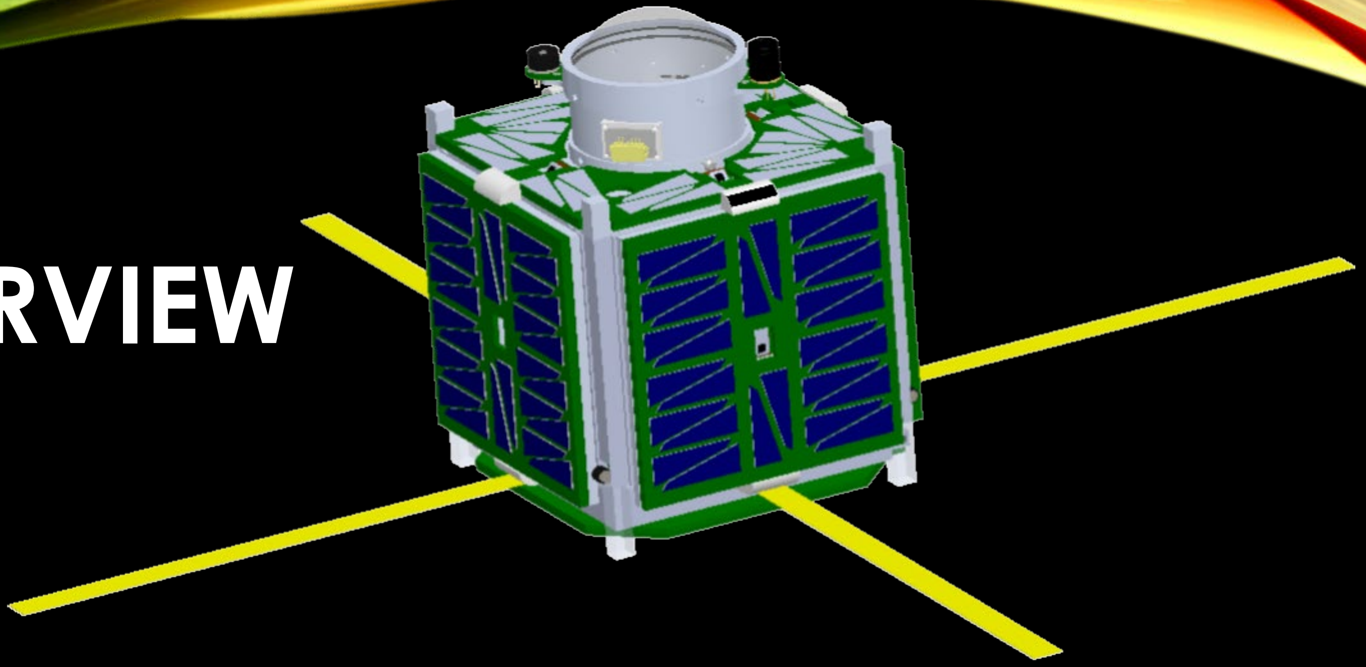
SSC20 -WKV-0

ARKSAT-1 OVERVIEW



- 1U CubeSat
- Scheduled to launch early 2021
  - (SpX-22 or SpX-23)
  - Originally manifested on SpX-21
- Hosts high-powered LED, which will be tracked from ground station
- Also tests Solid State Inflatable Balloon (SSIB) Deorbiting System
  - Applicable to Small Satellites (<180 kg)
  - PCB solid state gas generator (SSGG) chip
  - Space compatible balloon film structure
  - Spacecraft integration subsystem for modularity

SATELLITE DEVELOPMENT AT THE UNIVERSITY OF ARKANSAS

ARKSAT-1:
- 1U CubeSat, will use ISS as launch platform
- Initial flight demonstration for UA CubeSat
- Space Environment testing of SSIB Deorbiter Module
- Achieve LEO to surface atmospheric measurements
- High-power LED for ground tracking

Selected for launch under NASA's 8th Cubesat Launch Initiative (CSLI-8)

Launch early 2021

ARKSAT-2:
- 2U CubeSat, built on ARKSAT-1 infrastructure
- Chasing/tracking demonstration
- Novel CubeSat Agile Propulsion System (CSAPS) used for attitude control

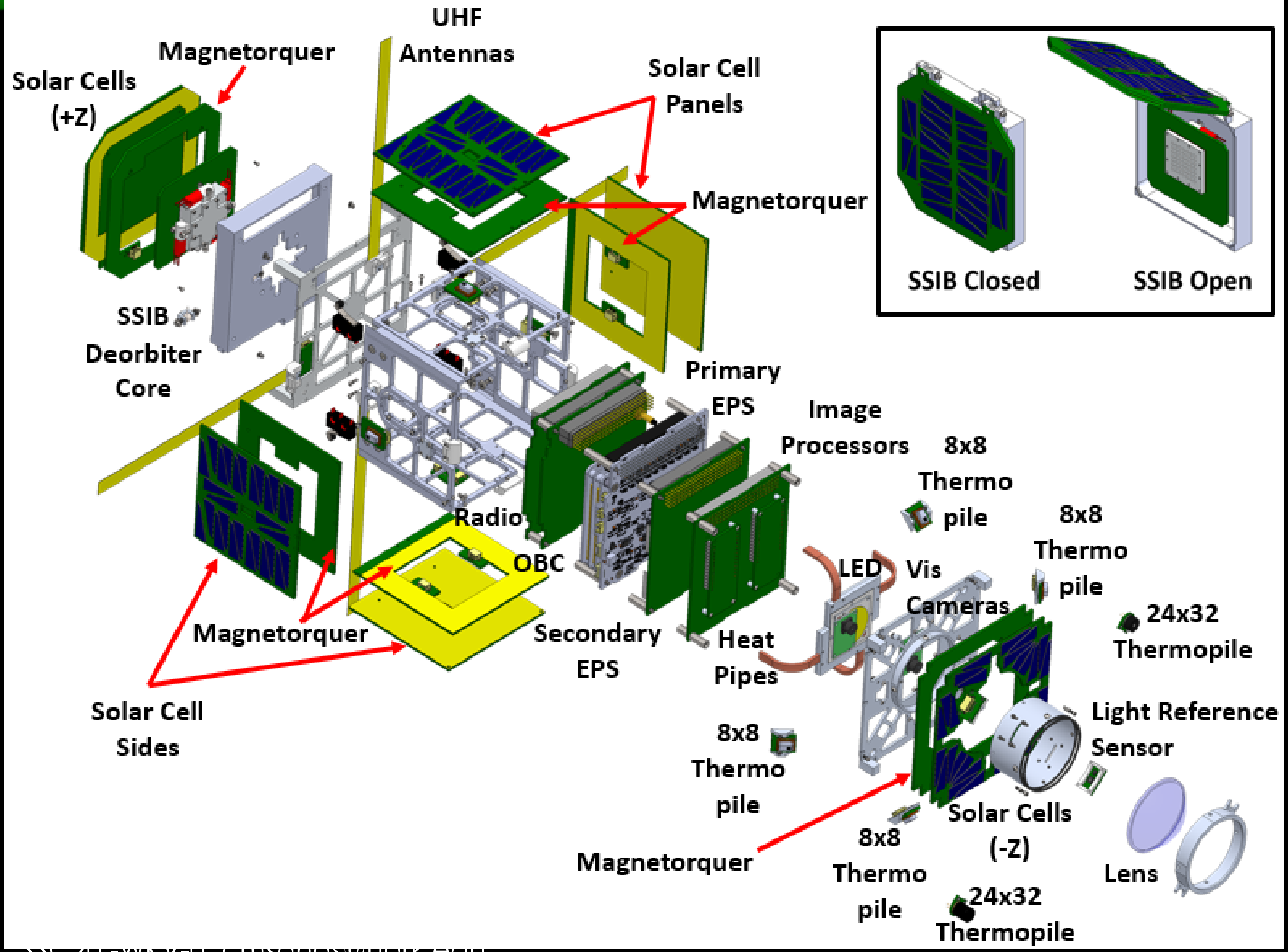
Launch via ISS Cygnus Resupply

Launch late 2021/early 2022

DAS-Cubes System:
- 1U & 2U CubeSat pair min. constellation size
- Combine tracking/chasing capabilities to achieve high-quality scientific measurements
- Can control distance and vector between spacecraft

Orbit details and delivery date under investigation

SPACECRAFT DESIGN AND HARDWARE



ARKSAT-1 SUBSYSTEMS

- Power Systems
  - 3J GaAs scrap solar cells on all six faces
  - Primary ClydeSpace 3G EPS w/ integrated 20-Whr batteries
  - Additional bank of ten 100mAh Li-po batteries
  - Secondary EPS to drive and control LED (36V nominal)
- High-Power LED (Primary Payload)
  - Luminus CXM-27 Gen 1 COB Arrays White LED, 11-12,000 lm, 119-130 lm/W
  - 50mm condenser lens on –Z face in "tuna-can" space of deployer
  - LED has apparent magnitude of ~3 at orbital altitude of 410km
  - Thermal requirements limit LED operation to ~10s
  - Heat pipes used to dissipate generated heat to AL side frames

ARKSAT-1 SUBSYSTEMS

- Sensors & Imaging
  - Input to attitude determination and control system (ADCS)
  - IR and optical image collection/downlink
  - AMG88 8x8 IR sensors for coarse Earth-sensing and nadir-pointing (all faces,9)
  - Melexis MLX90640 32x24 IR sensors for more accurate pointing (-Z, 2)
  - Putal PTC06, JPEG output optical TTL daytime ground tracking (-Z, 2)
  - TDK ICM-20948 9-axis MEMS gyro, accelerometer, and compass (all faces, 6)
  - Copper magnetic coils printed into PCBs on all faces
  - Nominal operational mode of nadir-pointing
  - Finer pointing mode to point spacecraft w/ LED to ground station

ARKSAT-1 SUBSYSTEMS

- Radio
  - Astrodev Lithium-1, half-duplex @435.45 MHz
  - Experimental LoRa RN2903 @906.3 MHz (uplink only)
  - Two ‘tape measure’ dipole antennas deployed w/ Nichrome burn wires
  - Ground station built on University amateur radio infrastructure
  - Hosts Li-1 radio identical to unit aboard spacecraft
  - Elliptically polarized Yagi antenna

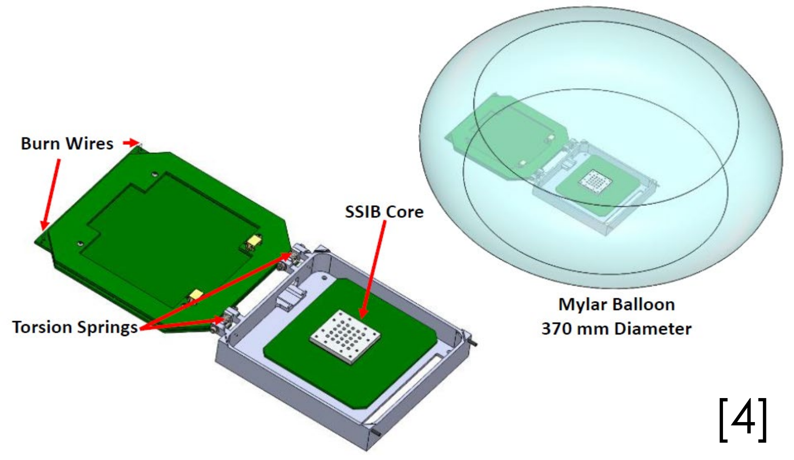
ARKSAT-1 SUBSYSTEMS

- Machining
  - All structure machined at the U of A student machine shop, including LED lens cap, housing
  - Center frame machined from 4"x4" square AL 6061 stock extrusion
    - 1/8" thick sidewalls
    - Ends (+/- Z face) milled from AL 6061 solid billets
    - Based on NASA Ames CubeSat design

SSIB DEORBITING SYSTEM

- Aerodynamic drag is dominant external force at CubeSat operational altitudes (300-550km)
- SSIB utilizes this force to reduce orbital lifetime of spacecraft
- Applicable to small sats (<180kg)
- Meets FAA requirements to deorbit within 25 years[4]

[4]



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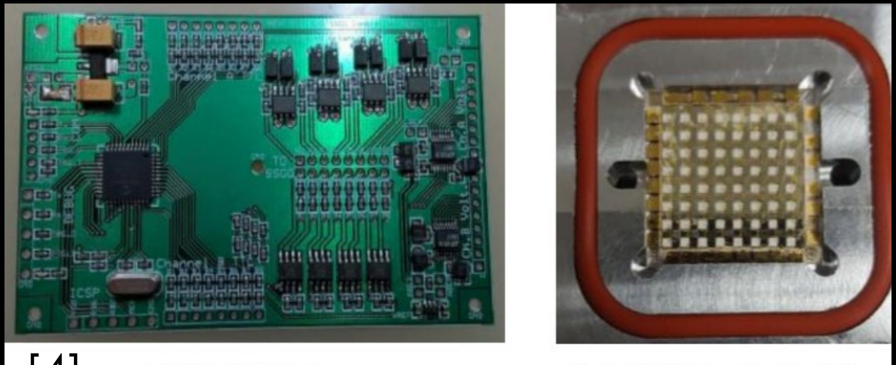
SSIB DEORBITING SYSTEM

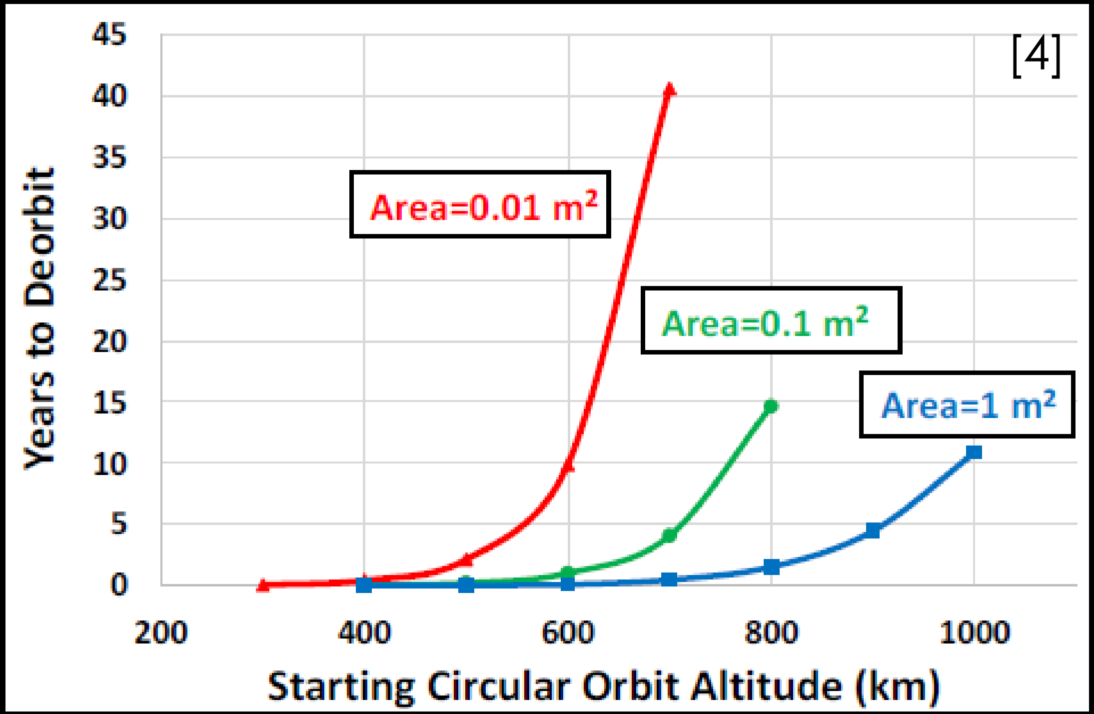
- Solid State Gas Generator (SSGG) chip with one 2D array of Sodium Azide (NaN_3) surrounded by balloon material
- When activated, heats up wells to >350°C, releasing N_2 gas
- Uses ~1W of power for ~10s
- Modular, fits within 10cm x 10cm x 2cm
- Wells coated with ~15μm parylene coating
- Toxicity well below toxic threshholds
- Shock tests showed no dislodging of material
- 10cm mylar balloon has been inflated at the UA in vacuum chamber at ~5mTorr



[4] 8x8 SSGG Driver 8x8 SSGG (with NaN_3)

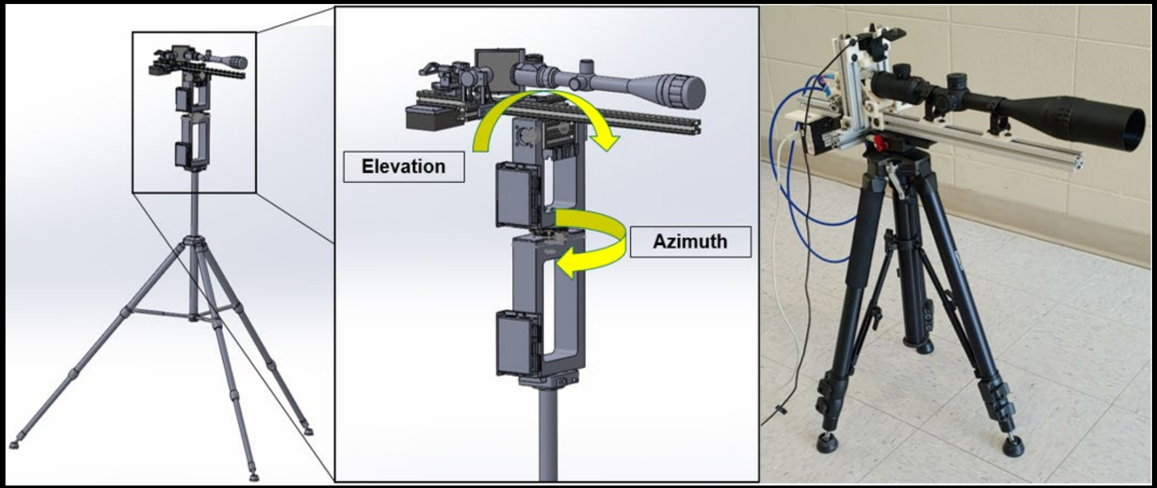
SSIB DEORBITING SYSTEM

- Simulations of orbital decay of different cross sectional areas performed using AGI STK
- Assumed 1.33kg 1U cubesat, 28.5° inclination
- ~37cm diameter balloon would significantly reduce lifetime
  - 40yr to <5yr at 700km initial orbit
  - ~2yr to <1yr at 550km initial orbit



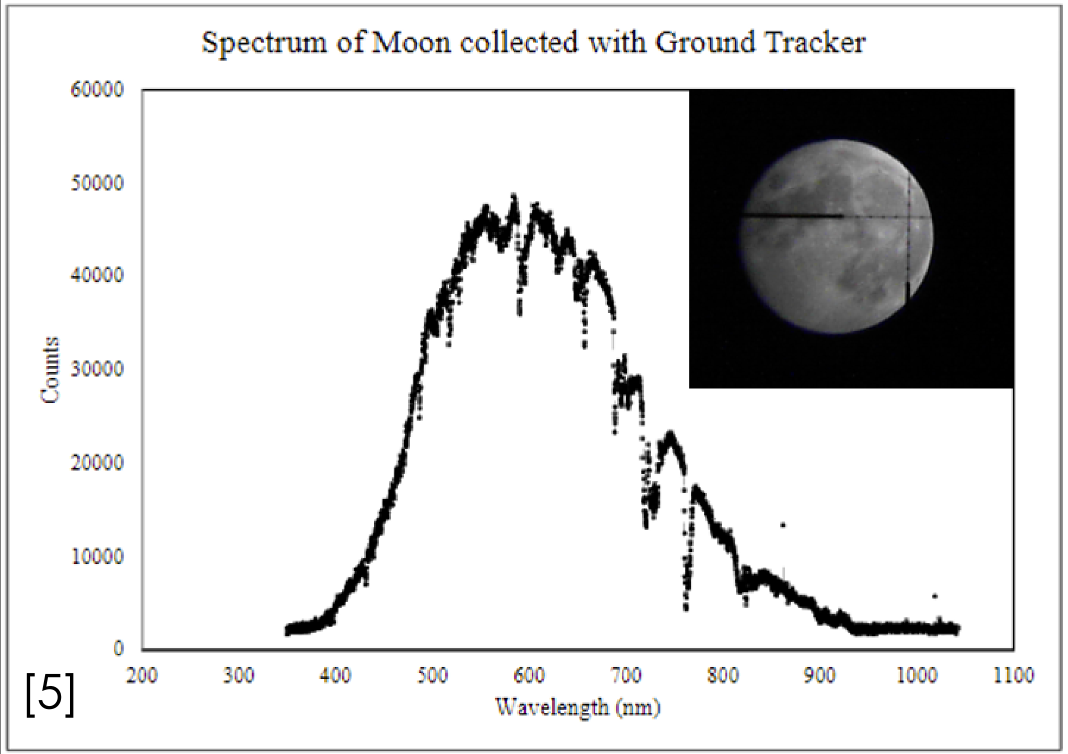
TRACKING SYSTEM & SPECTROSCOPY

- Ground-based aerial-tracking open path spectroscopic system
  - Emitter (ARKSAT-1)
    - LED light source
    - Sends location data, maintains pointing to ground tracker
  - Ground Tracker
    - Hosts Ocean Optics USB 4000 UV-Vis-NIR spectrometer to collect spectral data
    - Tracks emitter
    - Rifle Scope
    - Fiber optic cable
    - Camera
    - Lightweight AL frames
    - Two Nema high-accuracy stepper motors



TRACKING SYSTEM & SPECTROSCOPY

- Initial test in June 2019
- Lunar spectra collected
- Integration time of 1s
- Multiple absorption bands shown
- Can be compared with spectroscopic database such as HITRAN2016
- Future efforts to miniaturize and applied to satellite system



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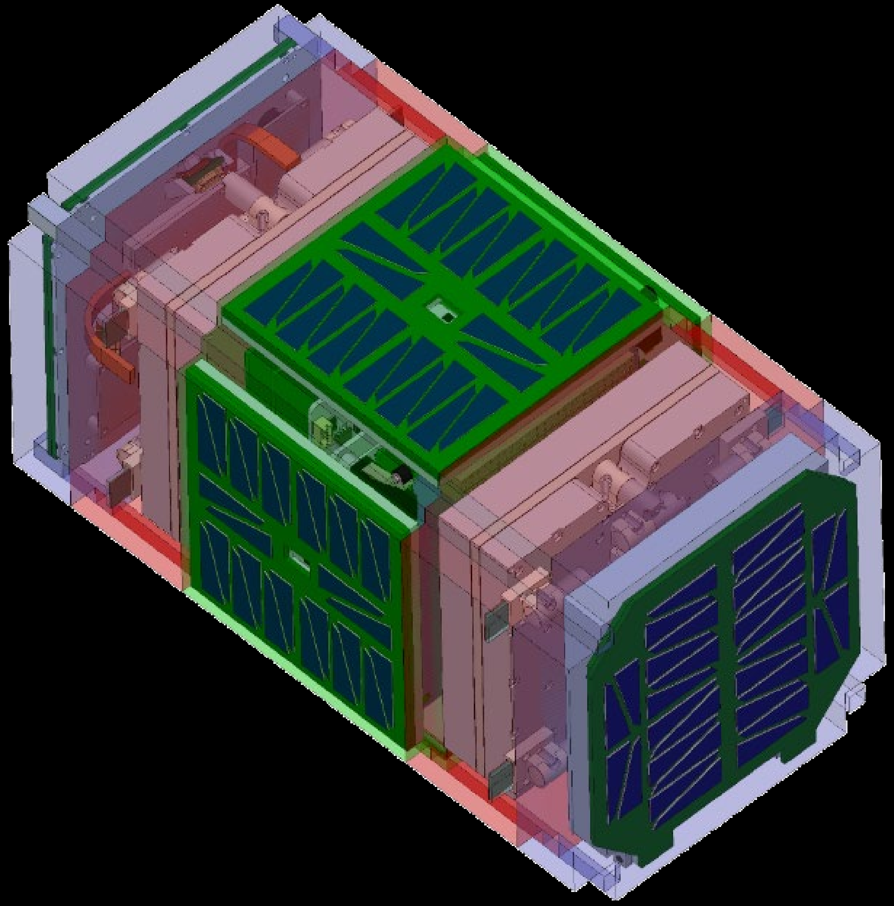
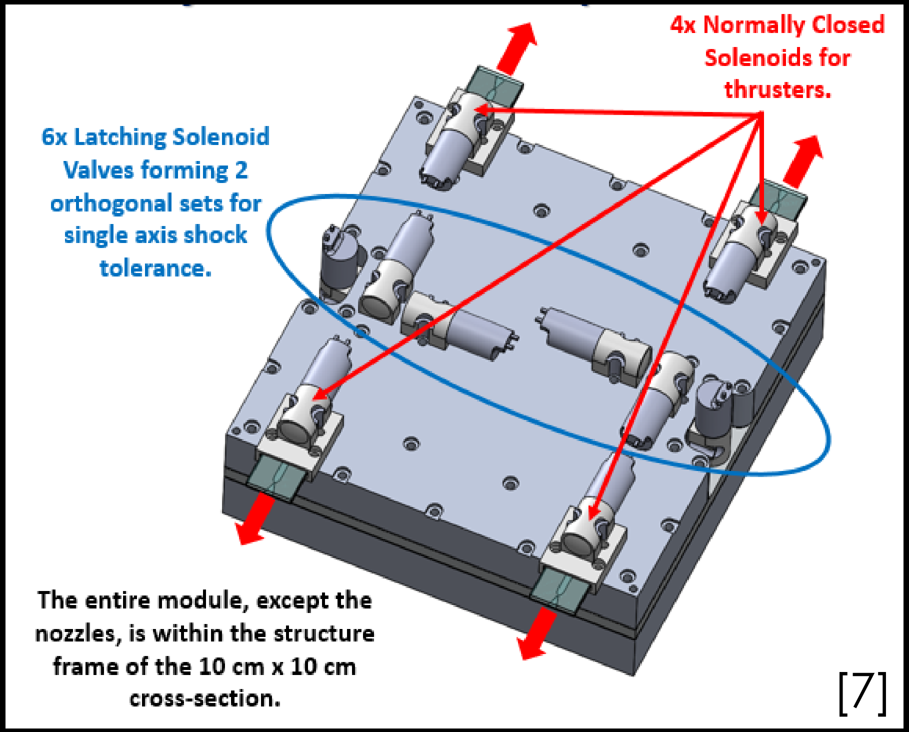
ARKSAT-2

- 2U Cubesat
- Built on ARKSAT-1 infrastructure
- Utilizes existing electronics stack
- Remaining ~1U allocated for novel CubeSat Agile Propulsion System (CSAPS), used for attitude control
- Expected launch date late 2021/early 2022



CSAPS PROPULSION SYSTEM

- Low-cost, biocompatible, non-toxic, non-flammabile, non-pressurized propulsion system
- Applicable to nano-sats (1-10kg)
- Produces milli-Newton thrust
- ~100s of ISP, Δv ~114 m/s[7]
- Propylene glycol chosen due to lower freezing pt, limiting expansion
- Four 10-mN nozzles, providing 4 DOF thrust
- No heating required for <60s, 10W integrated heater for longer maneuvers[7]



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DAS-CUBES SYSTEM

- Multi-small satellite system with separate emitter/receiver could remove many limitations from stellar and solar occultations and single platform measurements
  - Limb measurements only
  - Limited data acquisition times
  - Dependent on stellar and solar alignment
  - Minimal night side measurements
  - Nadir-pointing column abundances involve assumptions

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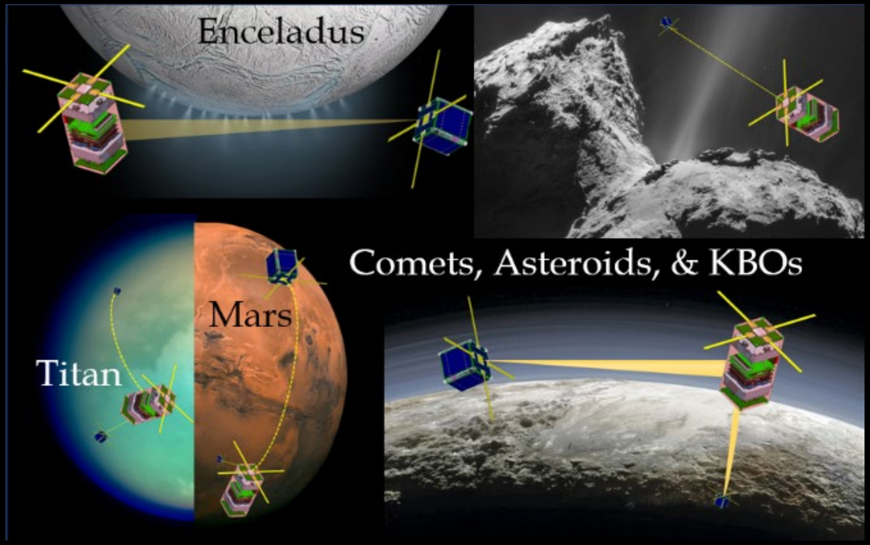
- Growing evidence for viability of interplanetary CubeSats/SmallSats
- MarCo as part of Mars InSight mission

DAS-CUBES SYSTEM



- Mars
  - Provide input into General Circulation Models
  - Volatile abundance and spatial/temporal variation (H_2O, CH_4)
- Titan
  - Some occultation measurements from Cassini, in-situ from Huygens probe
  - Little known about aerosol composition, methane variability
- Existing measurements would be greatly augmented by paired system with EM source of known intensity, spectrum, and source distance
- Multi small satellite system would greatly improve our understanding of planetary atmospheres

CONCLUSIONS

- ARKSAT-1, first student satellite in the state of Arkansas is scheduled to launch in early 2021
- Will constitute initial flight and operations demonstrations
- Payload of high power LED and SSIB small sat deorbiting system
- Follow on project of ARKSAT-2 w/ propulsion system
- Further investigations into use DAS-Cubes system for planetary science measurements

ACKNOWLEDGMENTS

The authors would like to thank the Arkansas Space Grant Consortium, NASA EPSCoR RID, and NASA EPSCoR-ISS (80NSSC17M0034) programs for funding support of this work

Special thanks to our collaborators Dr. Yupo Chan of UA Little Rock and Dr. Ed Wilson of Harding University

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