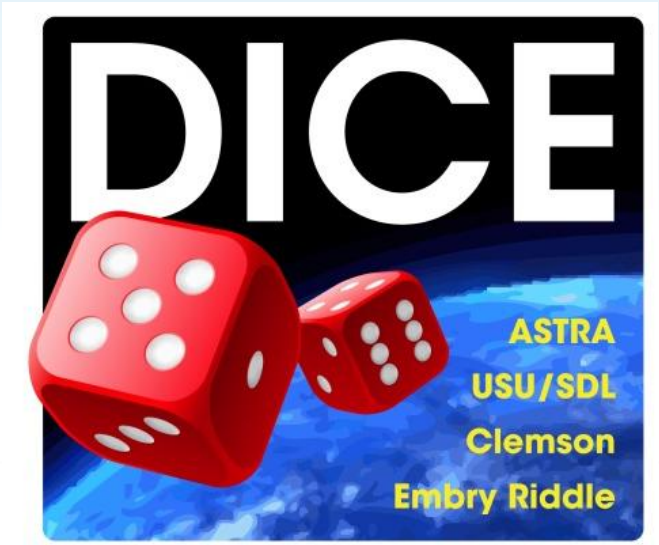
Space Dynamics Laboratory
Utah State University Research Foundation

DICE CubeSat Mission

Spring 2011 CubeSat Workshop April 20, 2011

Erik Stromberg, erik.stromberg@sdl.usu.edu



Space Dynamics LABORATORY
Utah State University Research Foundation

EMBRY-RIDDLE
Aeronautical University

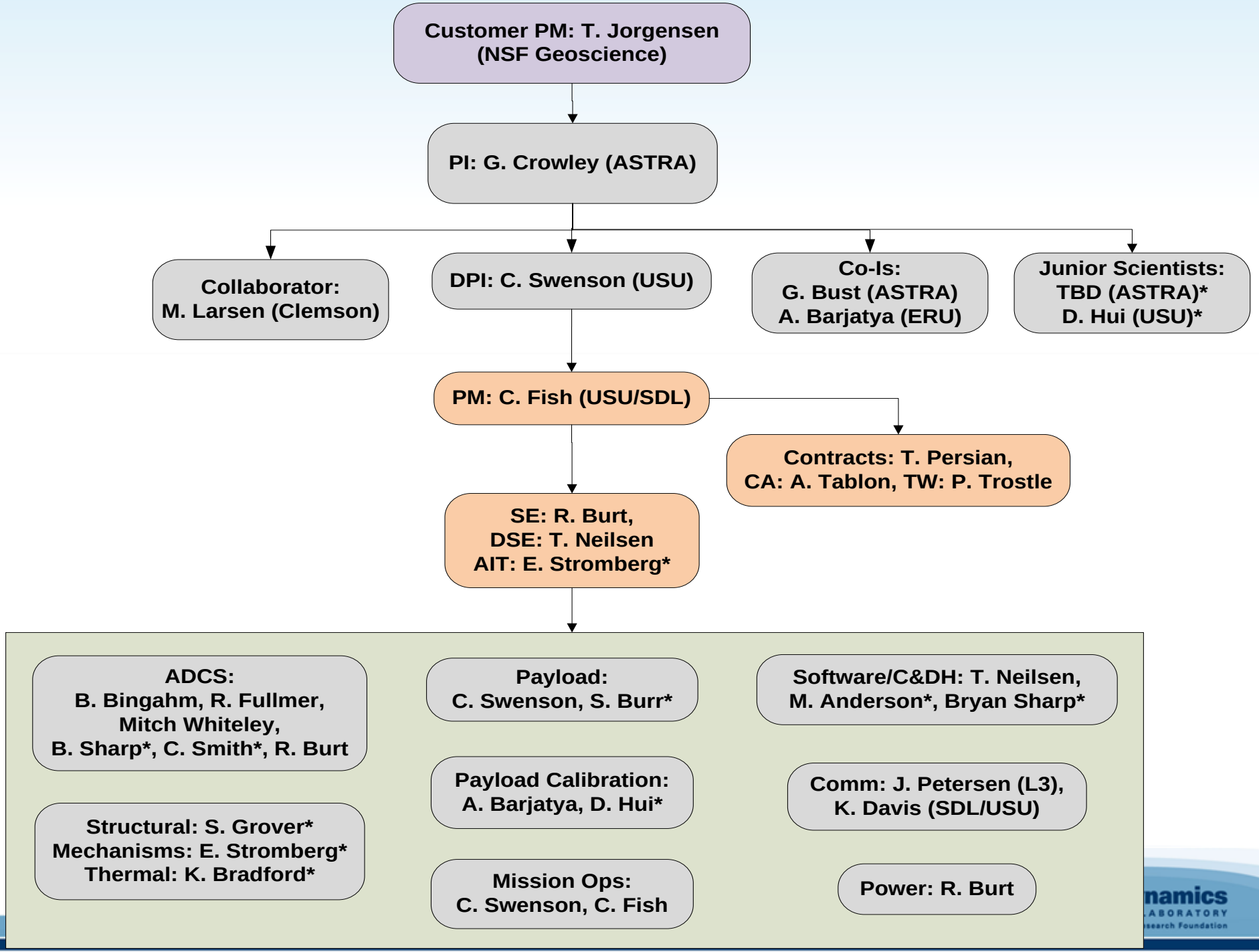
CLEMSON
UNIVERSITY

UtahStateUniversity

The Dynamic Ionosphere CubeSat Experiment

PI:	*Geoff Crowley, Astra*
DPI:	*Charles Swenson, Utah State*
Co-I:	*Aroh Barjatya, Embry Riddle*
Co-I:	*Gary Bust, Astra*
Collaborator:	*Miguel Larsen, Clemson*

NSF-Funded Dual-satellite Space Weather Mission


Customer PM: T. Jorgensen
(NSF Geoscience)
PI: G. Crowley (ASTRA)
Collaborator:
M. Larsen (Clemson)
DPI: C. Swenson (USU)
Co-Is:
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A. Barjatya (ERU)
Junior Scientists:
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D. Hui (USU)*
PM: C. Fish (USU/SDL)
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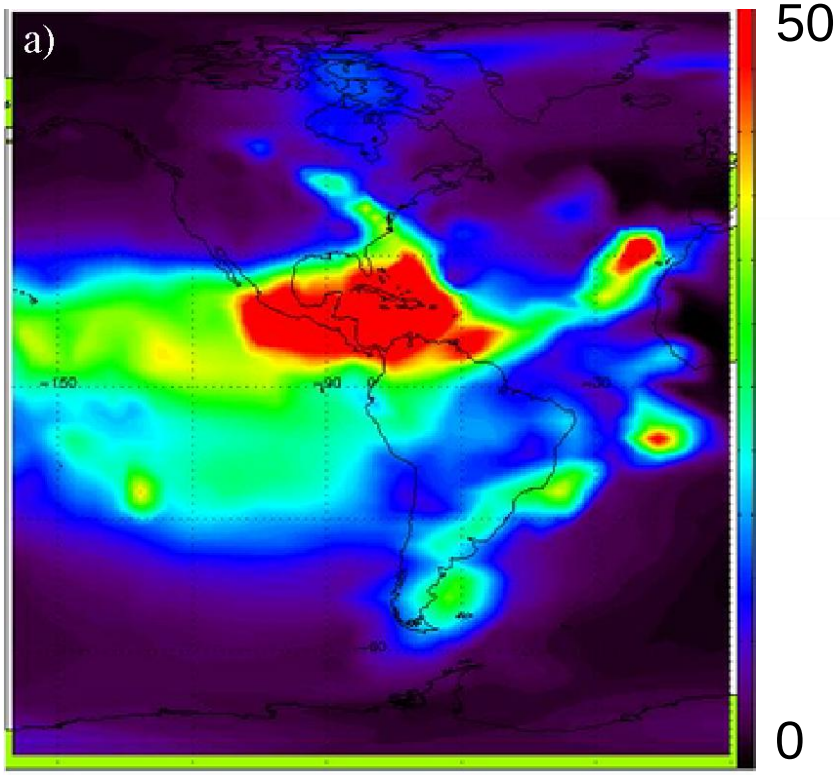
CA: A. Tablon, TW: P. Trostle
SE: R. Burt,
DSE: T. Neilsen
AIT: E. Stromberg*
ADCS:
B. Bingahm, R. Fullmer,
Mitch Whiteley,
B. Sharp*, C. Smith*, R. Burt
Payload:
C. Swenson, S. Burr*
Software/C&DH: T. Neilsen,
M. Anderson*, Bryan Sharp*
Payload Calibration:
A. Barjatya, D. Hui*
Comm: J. Petersen (L3),
K. Davis (SDL/USU)
Structural: S. Grover*
Mechanisms: E. Stromberg*
Thermal: K. Bradford*
Mission Ops:
C. Swenson, C. Fish
Power: R. Burt

DICE Team Photo

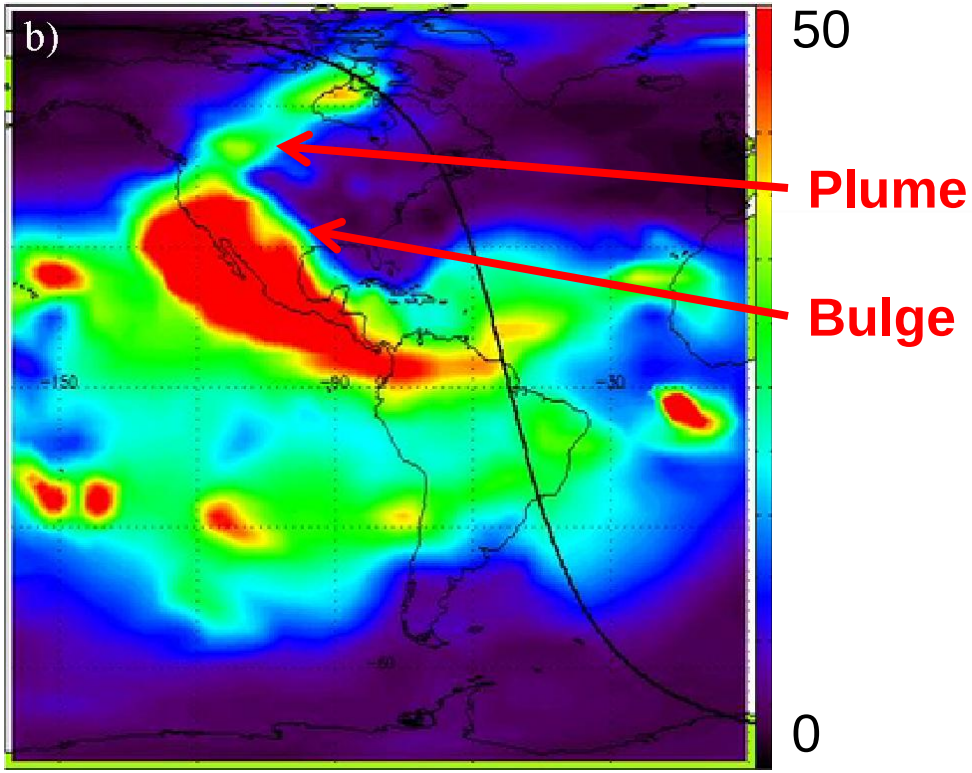
10+ Students and ~5 Professionals

Science Motivation

November 20, 2003 storm



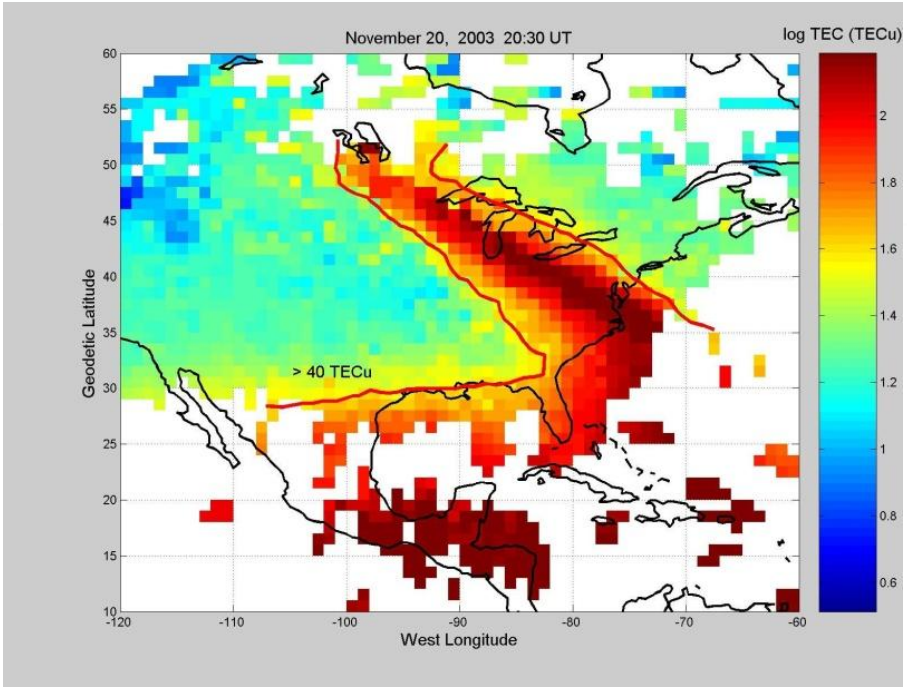
October 30 2003 storm



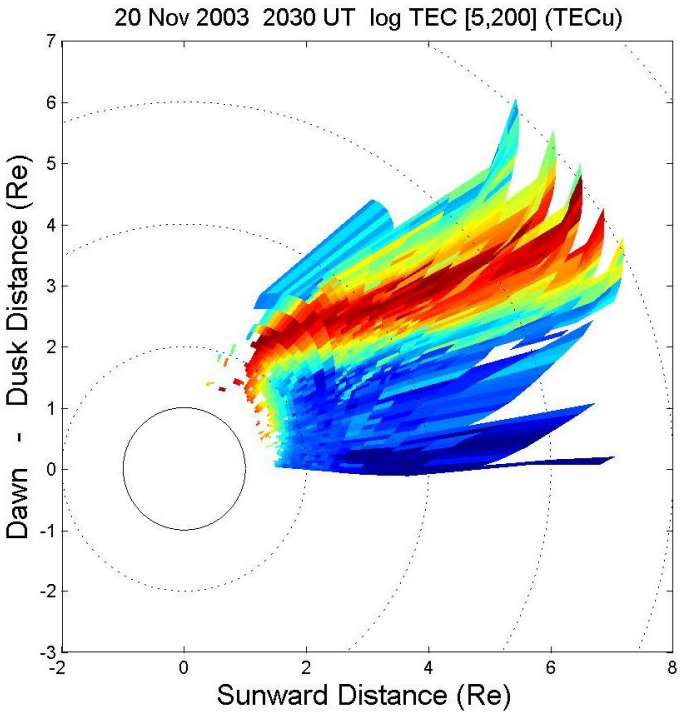
Horizontal distribution of peak electron density from 4D simulations

Science Motivation

TEC Plume Mapped to Equatorial Plane

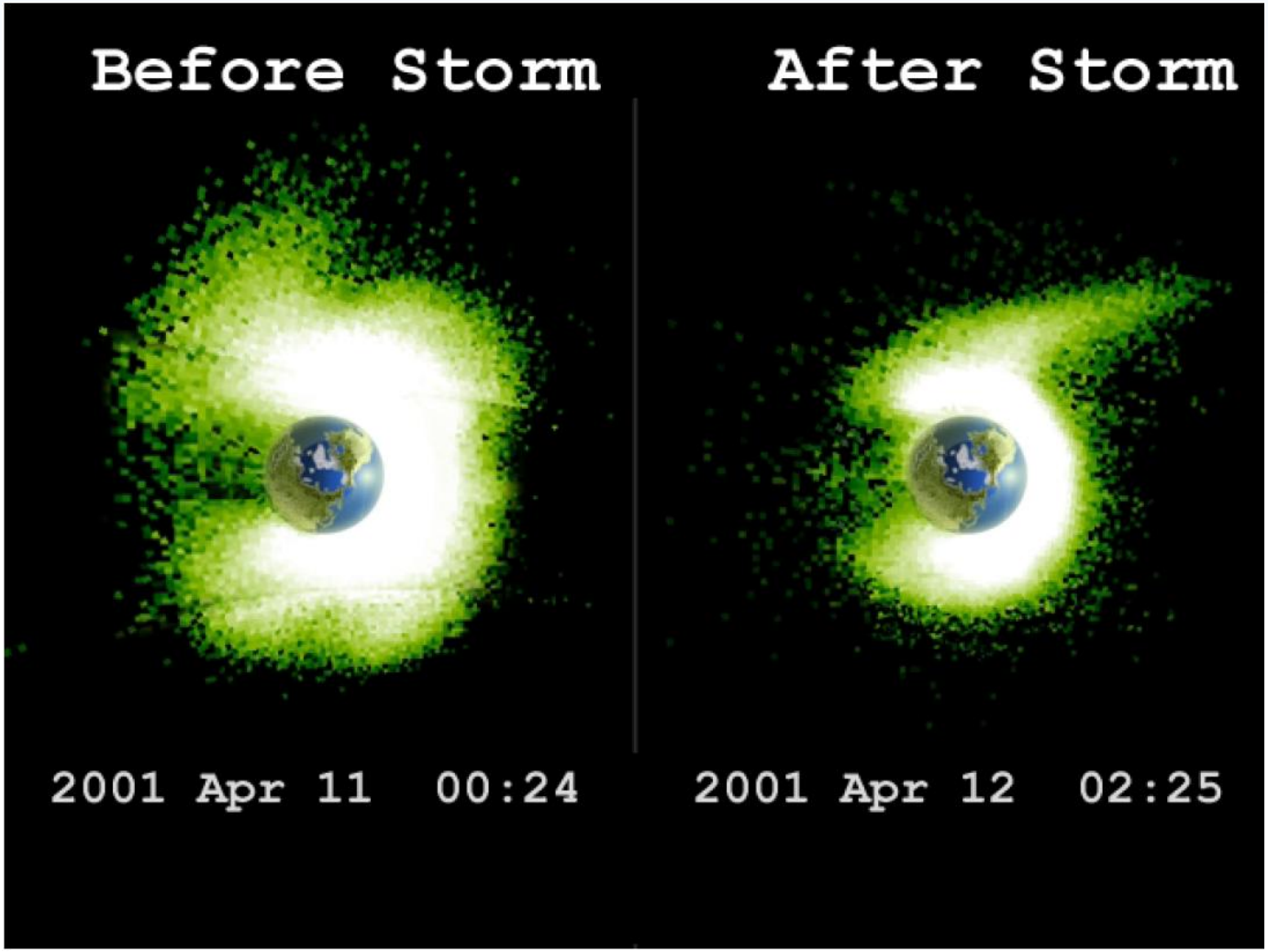


Foster et al, JGR 2004



John Foster
MIT Haystack
Observatory

Science Overview

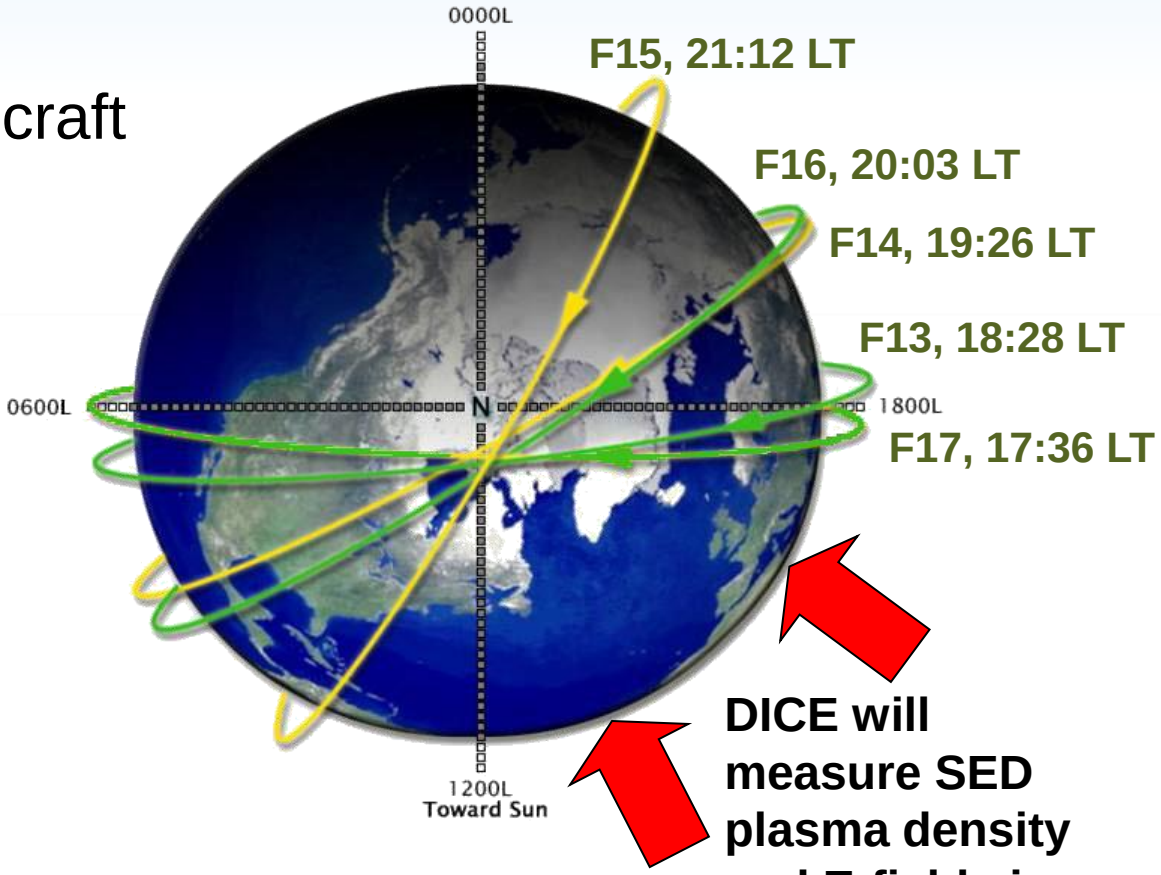


Science Objectives

1. Investigate the physical processes responsible for formation of the geomagnetic Storm Enhanced Density (SED) bulge in the noon to post-noon sector during magnetic storms.
2. Investigate the physical processes responsible for the formation of the SED plume at the base of the SED bulge and the transport of the high density SED plume across the magnetic pole.
3. Investigate the relationship between the penetration electric fields and the formation and evolution of SED:

Mission

- **Two** spinning spacecraft
  - Leader – follower
  - ~0.2 Hz
  - Geodetic alignment
- > 55º Inclination
- 350 – 550 km Alt
- 90 day mission
  - Goal 6 months



DICE will measure SED plasma density and E-fields in key afternoon sector.

Science Requirements

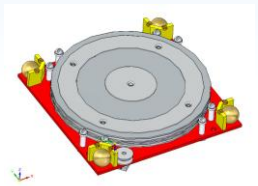
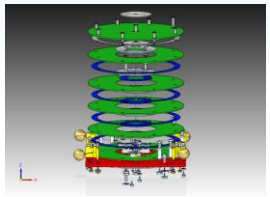
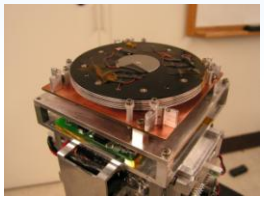
- Measure Electron Density
- Measure E-fields (plasma drift)
- Sun-Synchronous orbit in the 12-16LT range is ideal
- Time-resolution of the measurements matches the scale-size of the features to be observed (1000km @ 7km/s = 14s; cadence of 0.5 to 1 seconds for the plasma and electric field measurements)
- AC electric field spectrum measurements (irregs)

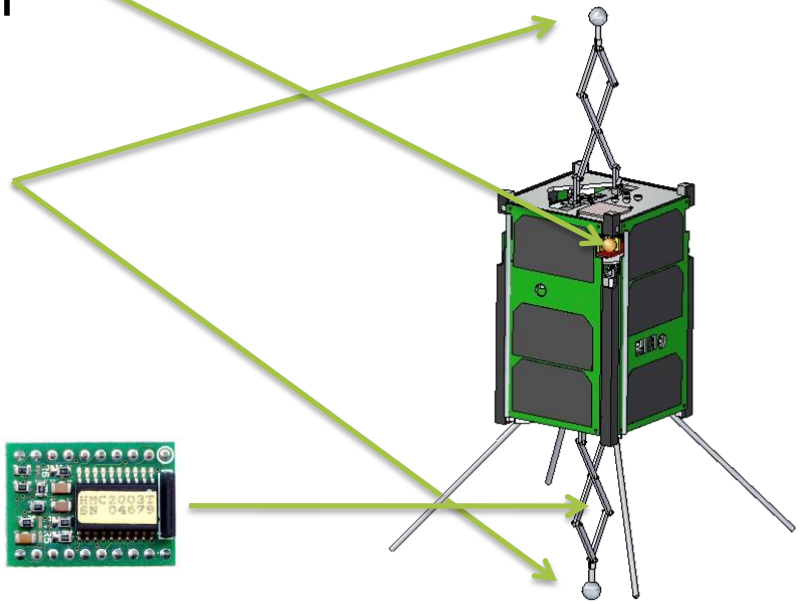
- Expect 1 SED per month
- 6-month mission yields 6 SED events

- Two 1.5U (10 x 10 x 15 cm) CubeSats
- Common high-inclination pearls-on-a-string orbit
- The two satellites will remain within ~300 km of one another for up to six months, allowing temporal-spatial deconvolution
- Each satellite will carry identical instrumentation

Science Instrumentation

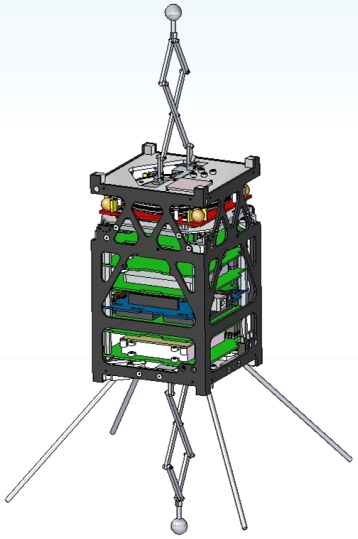
- Electric Field ~0.2 mV/m
  - Double Probe Technique
  - 10 m wire booms
  - ~80 Hz sample rate
- Plasma Density ~$10^2 cm^{-3}$
  - Dual Langmuir Probes
  - ~80 Hz sample rate
- Magnetic Field ~5 nT
  - Dual Magnetometers
  - ~80 Hz sample rate

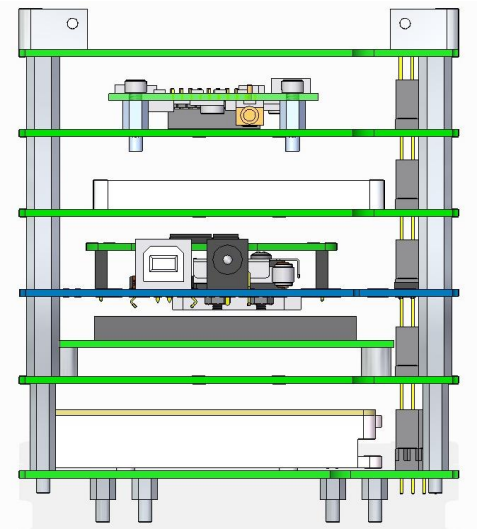






DICE Spacecraft

- Pumpkin C&DH System
- SDL/USU Science board
- L3 Radio
  - 1.5 Mbit/s down link
- Sun + Magnetometer
  - 0.1º Post flight
- Power
  - ~1.5 W spacecraft
  - ~200 mW payload





Instrument Electronics

ADCS Board with GPS Module

Z-axis Torque coil

C&DH Board with Processor

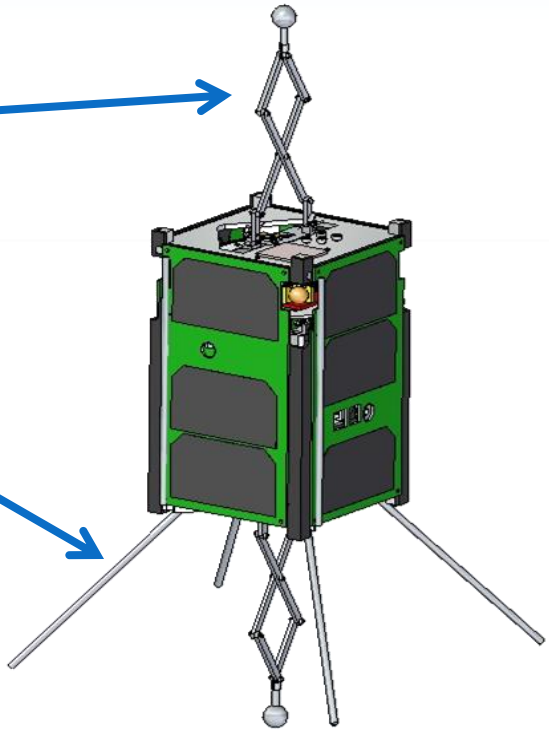
EPS and Battery Board

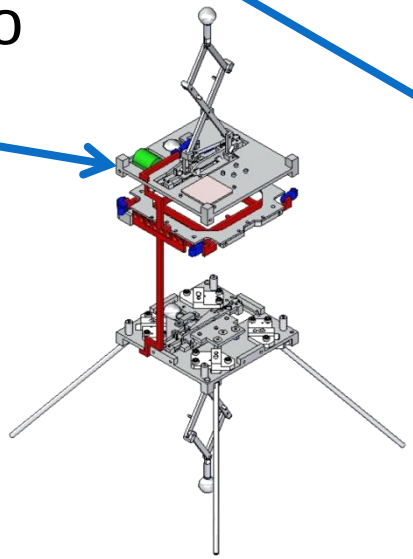
Comm Board with L3 Radio

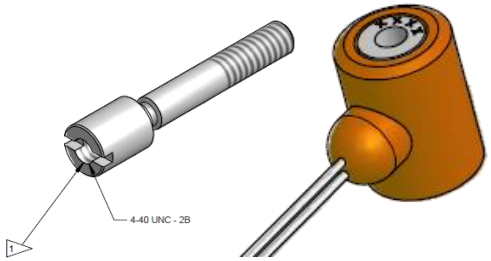
Coil Wrapping

Antennas and Booms

- EFP Booms - 5m
  - 10 m tip to tip
- DCP + Mag- 8cm
- UHF Comms – 14cm
  - (460 – 470 MHz, 1.5 Mbit)
- TiNi Aerospace Micro Frangibolt







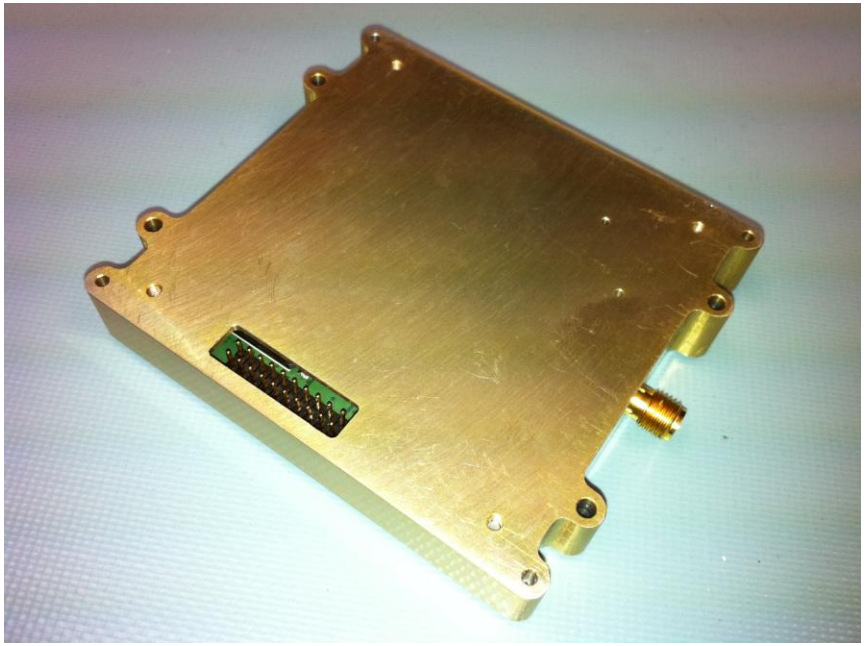
Selected for Launch

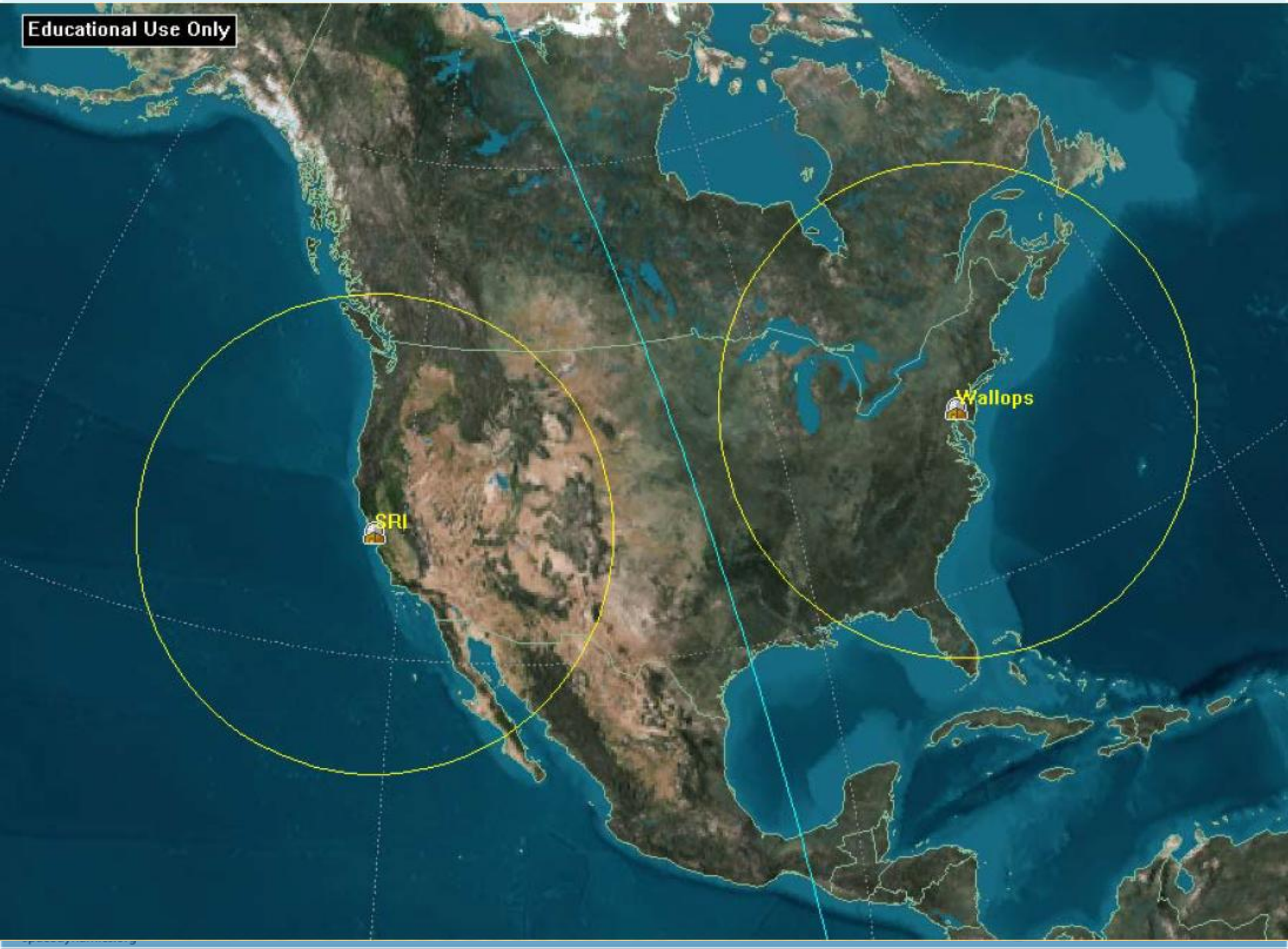
- Selected for launch on the NASA's ELaNa 3 mission
- NPP (NPOESS Preparatory Project)
- Inclination 102 degrees
- 830 x 350 km (circularize over 2 yrs)
- Scheduled delivery to Cal Poly prior to July 11th, 2011
- Scheduled launch date of October 25th, 2011

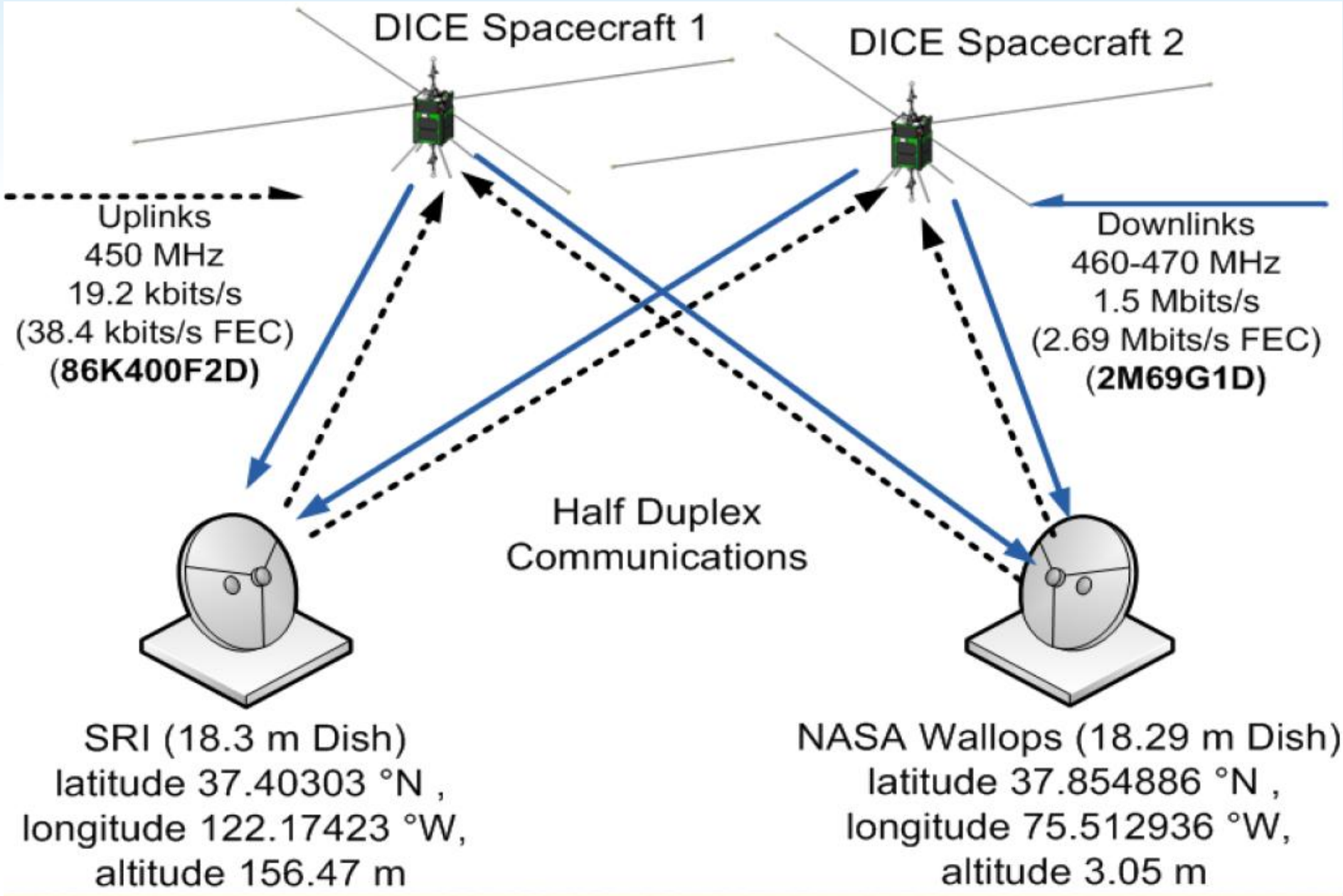
- Ground-stations:
  - NASA Wallops Island
  - SRI International

L3 Cadet Radio

- Custom designed high-speed downlink UHF radio
- Designed and built by L3 Communications
- Tested and debugged by L3 and SDL Engineers

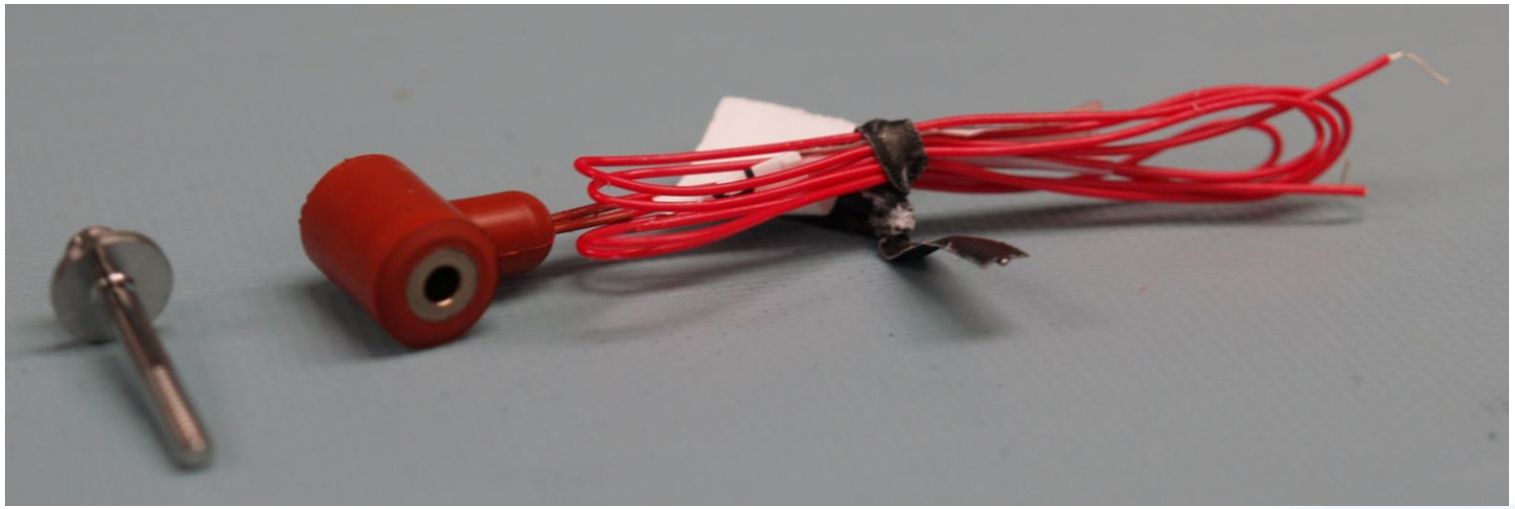



Educational Use Only
SRI
Wallops

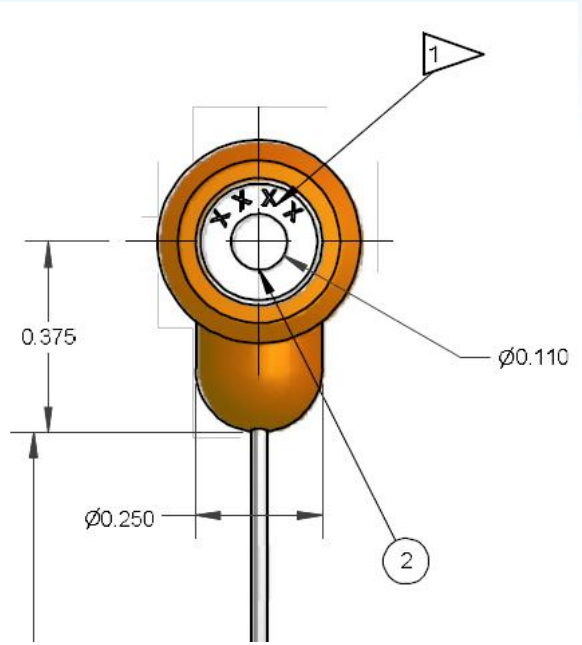

DICE Spacecraft 1
DICE Spacecraft 2
Uplinks
450 MHz
19.2 kbits/s
(38.4 kbits/s FEC)
(86K400F2D)
Downlinks
460-470 MHz
1.5 Mbits/s
(2.69 Mbits/s FEC)
(2M69G1D)
Half Duplex
Communications
SRI (18.3 m Dish)
latitude 37.40303 °N ,
longitude 122.17423 °W,
altitude 156.47 m
NASA Wallops (18.29 m Dish)
latitude 37.854886 °N ,
longitude 75.512936 °W,
altitude 3.05 m

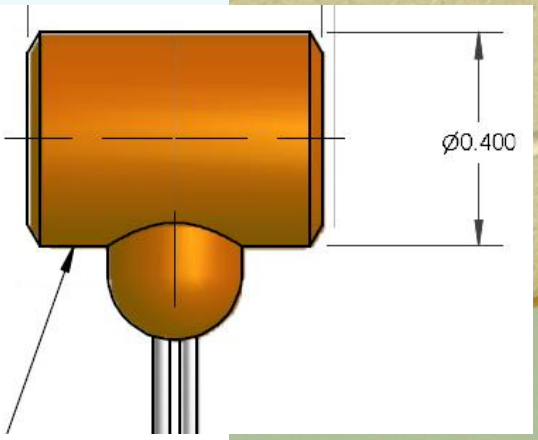
TINI Aerospace Frangibolt

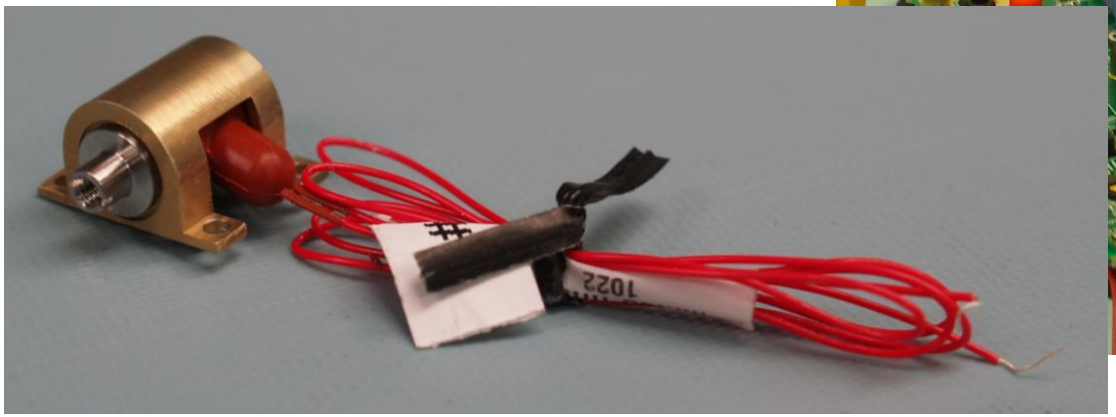
- Aerospace Quality
- The P-Pod is not a containment unit
- Must meet safety requirements for deployable structures
- ~0.5 x 0.4 inch in size



TINI Aerospace Frangibolt

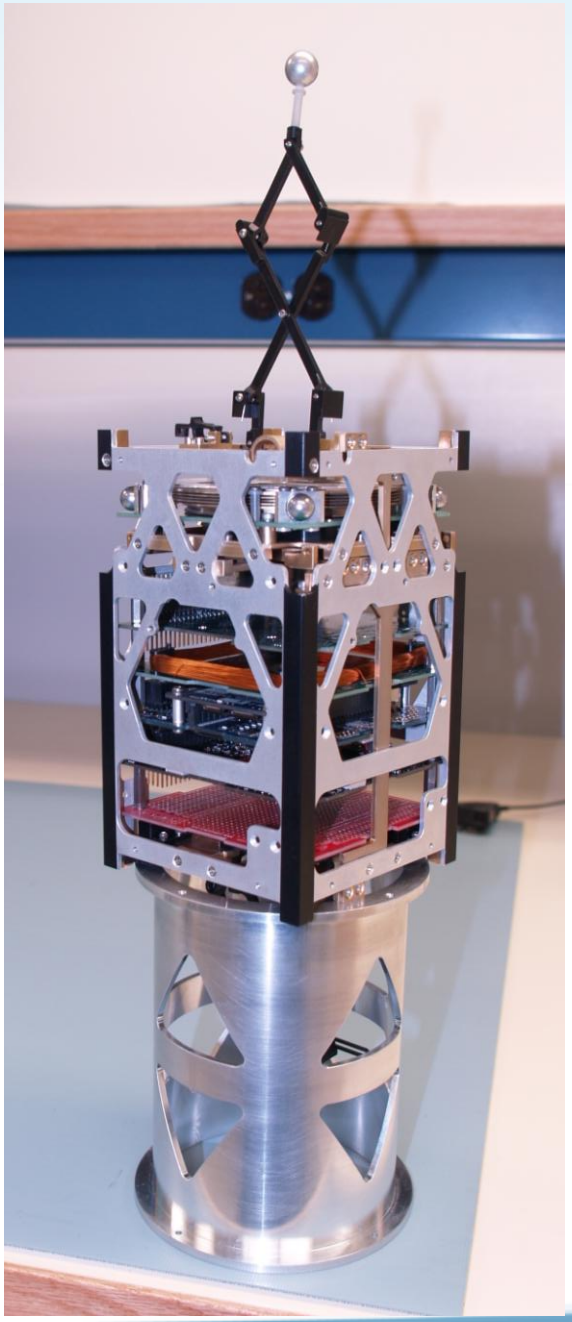


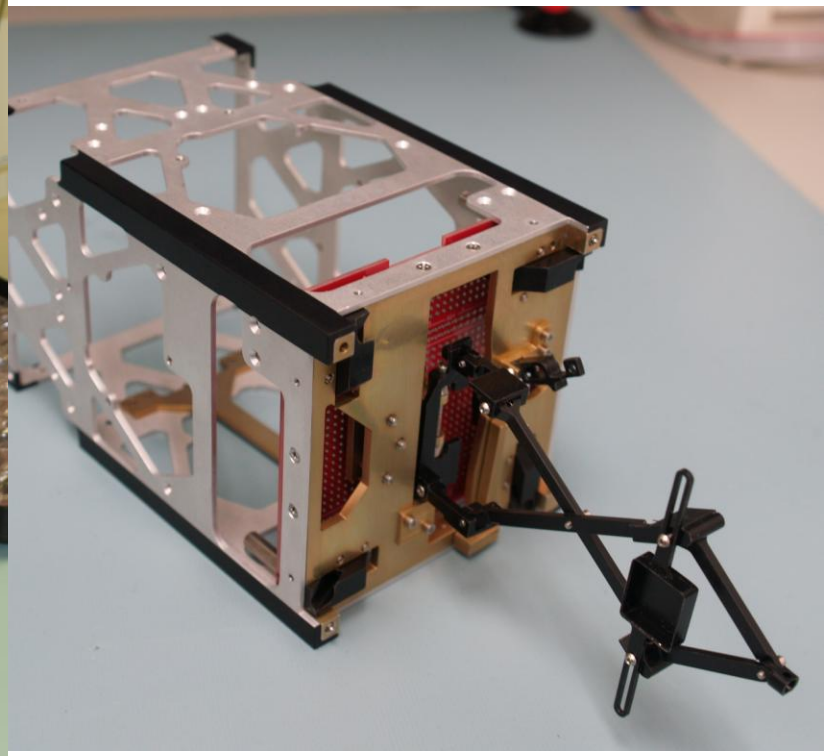




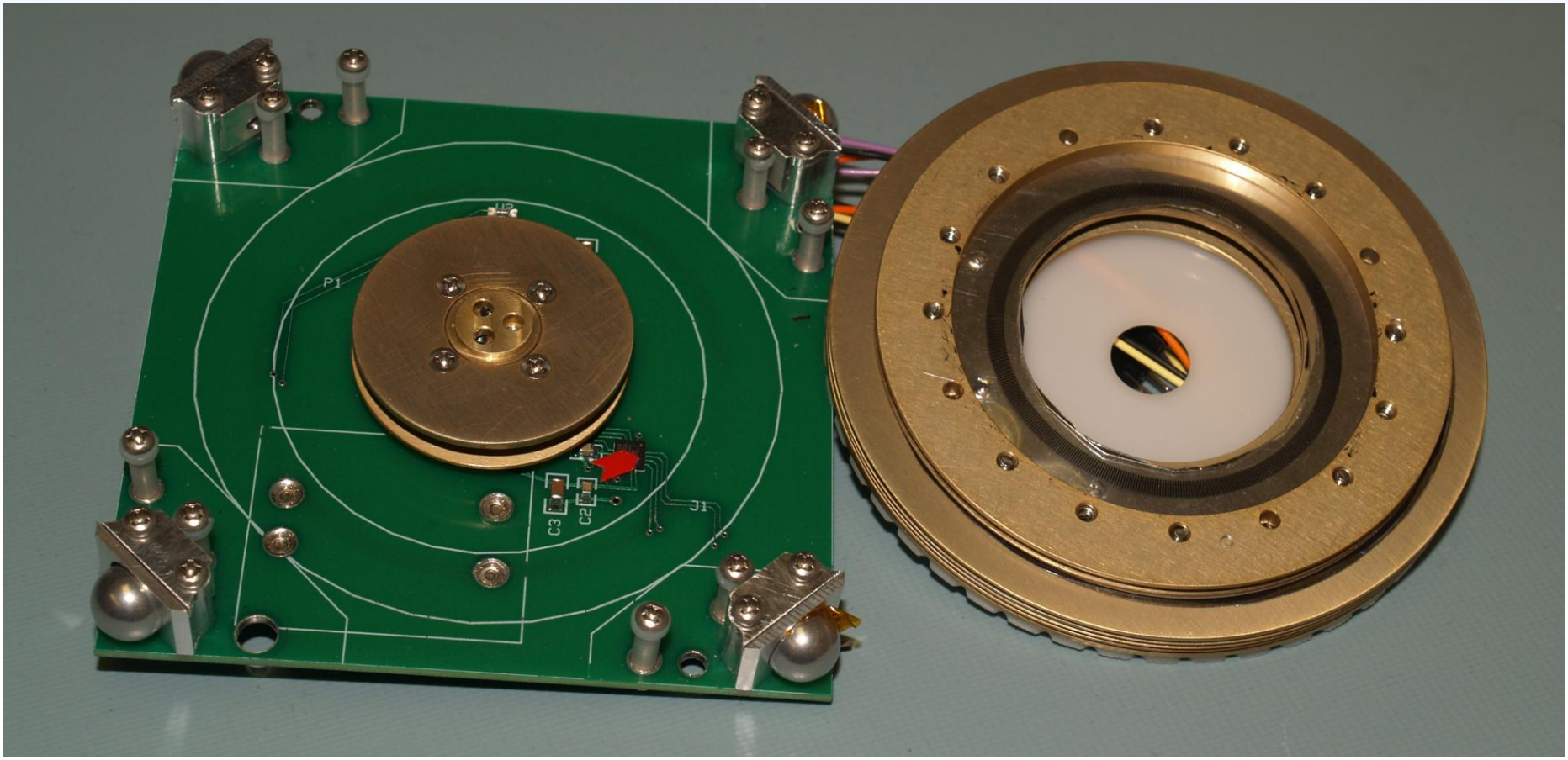
TINI Aerospace Frangibolt

Spacecraft Pictures

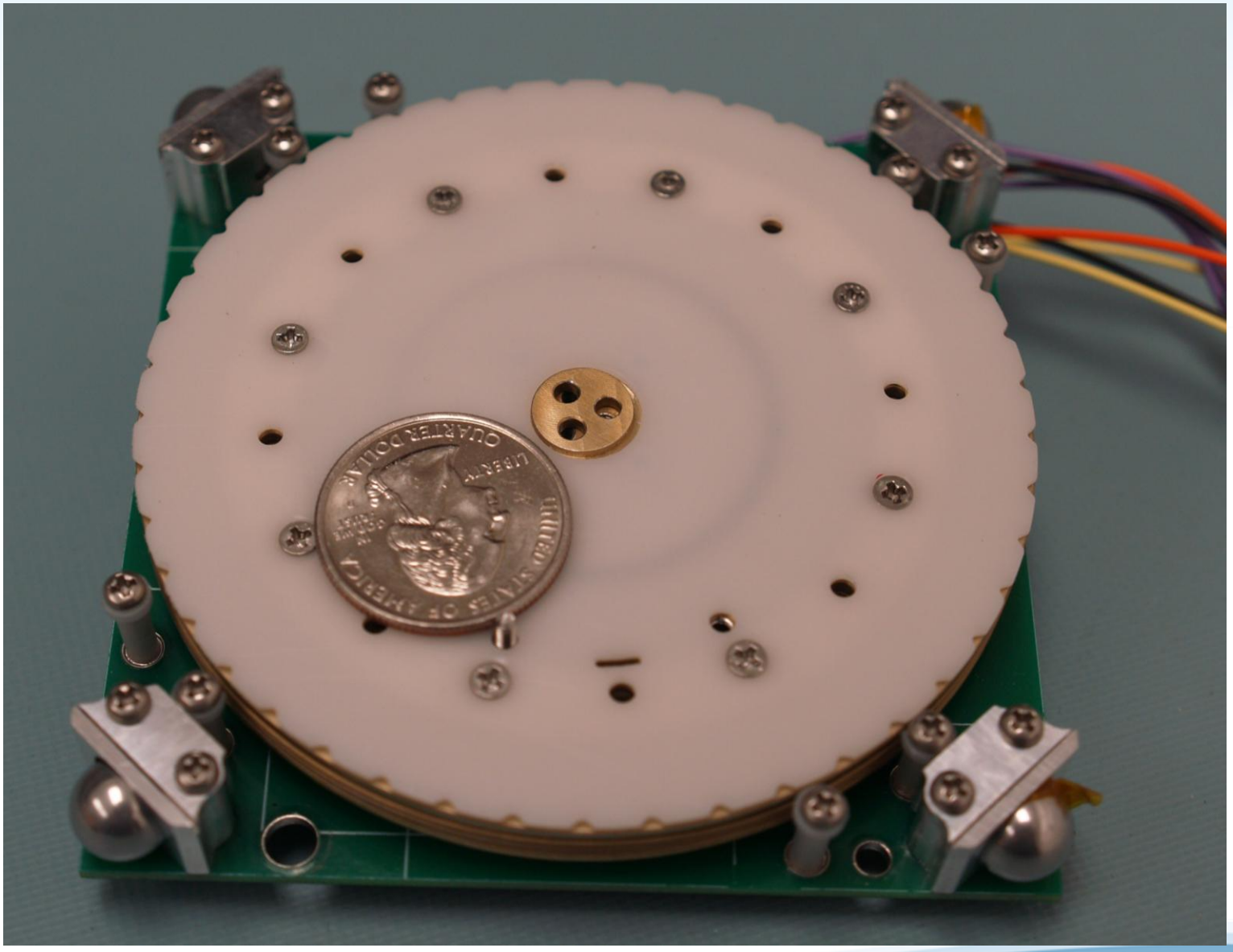




E-Field Instrument



E-Field Instrument



E-Field Instrument Testing

- Performing spin deployment tests to try and characterize the behavior of the instrument as booms are released
- Characterized friction on center bearing
- Characterized minimum spin rate for proper deployment

- Currently finalizing design of motor control
- Once completed, will spin deploy booms using controlled release and characterize spacecraft reactions to deployment

E-Field Instrument Testing

Vibration and Thermal

- Currently performing calibration and preliminary thermal environment testing
- Satellite temperature varies from -10 – 45 degrees Celsius
- Run electronic and sweep calibration at the high and low temperatures

- Vibe tests schedules within the next two weeks
- Plan to use in-house SDL vibe platform
- Custom designed interface to P-Pod for table

Lessons Learned on ELaNa

- Don’t be afraid to ask questions
- Hold to deadlines of surveys and forms necessary
- Build in extra time in case of slippage
- READ THE ICD

- Keep Cal Poly and ELaNa folks in the loop of CubeSat status often
- Plan on letting Cal Poly folks look at test plans to ensure that proper levels will be reached

Questions?