DICE CubeSat Mission

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Erik Stromberg, erik.stromberg@ SDL.usu.edu
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
DICE Team Photo

10+ Students and ~5 Professionals
Science Motivation

Horizontal distribution of peak electron density from 4D simulations

November 20, 2003 storm

October 30 2003 storm

Plume

Bulge
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
- > 55° Inclination
- 350 – 550 km Alt
- 90 day mission
  - Goal 6 months

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

F17, 17:36 LT
F16, 20:03 LT
F15, 21:12 LT
F14, 19:26 LT
F13, 18:28 LT
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 \( \sim 0.2 \text{ mV/m} \)
  - Double Probe Technique
  - 10 m wire booms
  - \( \sim 80 \text{ Hz sample rate} \)

- Plasma Density \( \sim 10^2 \text{cm}^{-3} \)
  - Dual Langmuir Probes
  - \( \sim 80 \text{ Hz sample rate} \)

- Magnetic Field \( \sim 5 \text{ nT} \)
  - Dual Magnetometers
  - \( \sim 80 \text{ Hz sample rate} \)
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
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
DICE Spacecraft 1

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

Spacedynamics.org
Space Dynamics Laboratory
Utah State University Research Foundation
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?