Scintillation Observations and Response of The Ionosphere to Electrodynamics (SORTIE)

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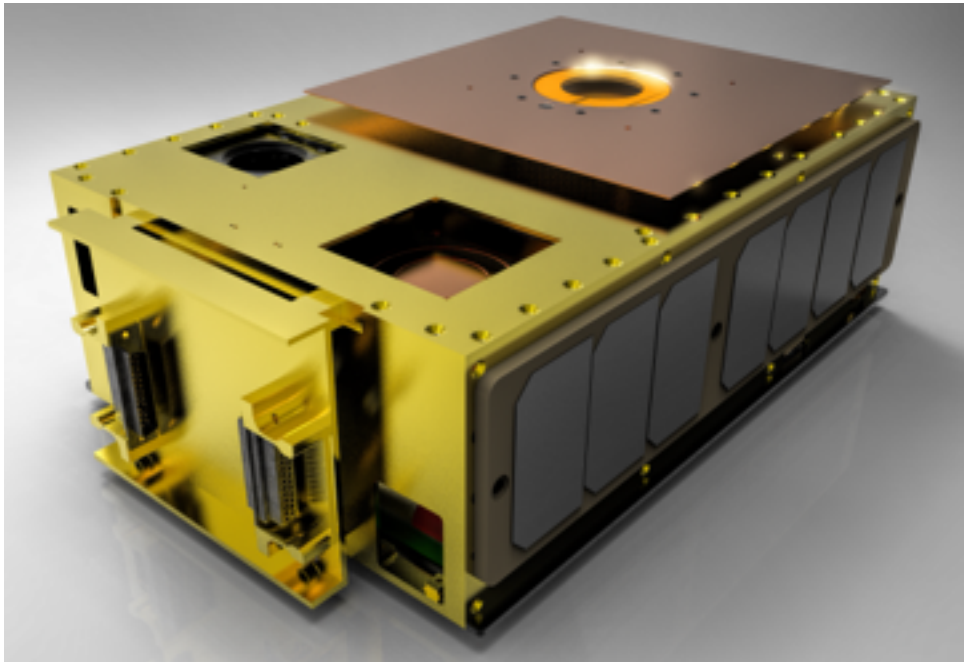
SORTIE Mission Overview

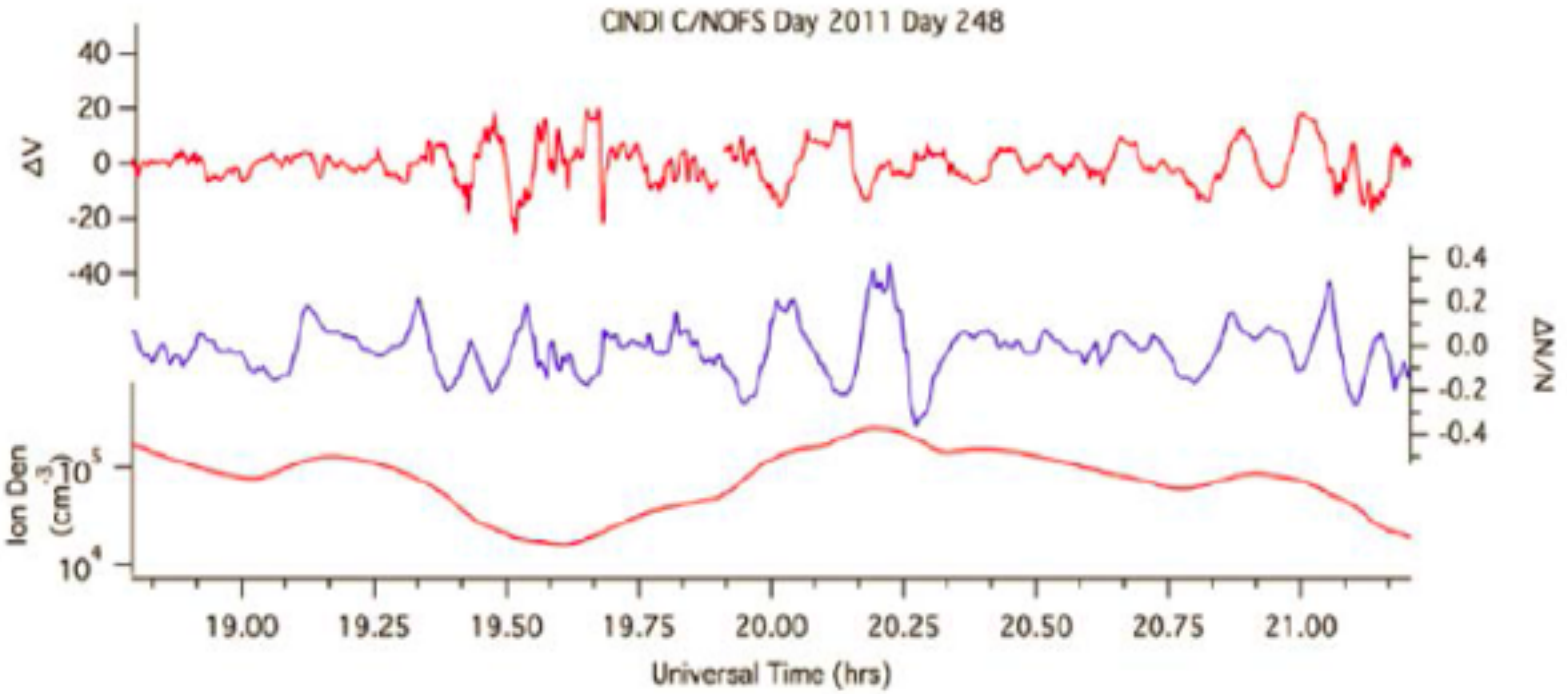
❖Science
❖ Technology
❖ Applications
Bringing It All Together

ASTRA

- 6U CubeSat Mission
- Team Members:
  - NASA
  - ASTRA
  - AFRL
  - UTD
  - COSMIAC
  - Boston College
- Slated to launch late Fall 2017 (CSLI manifest)
  - Provide overlap with NASA's ICON mission
- CDR in May
- 1 Year of on-orbit lifetime
- Low to mid inclination orbit near 350-400km, circular



SORTIE Objectives

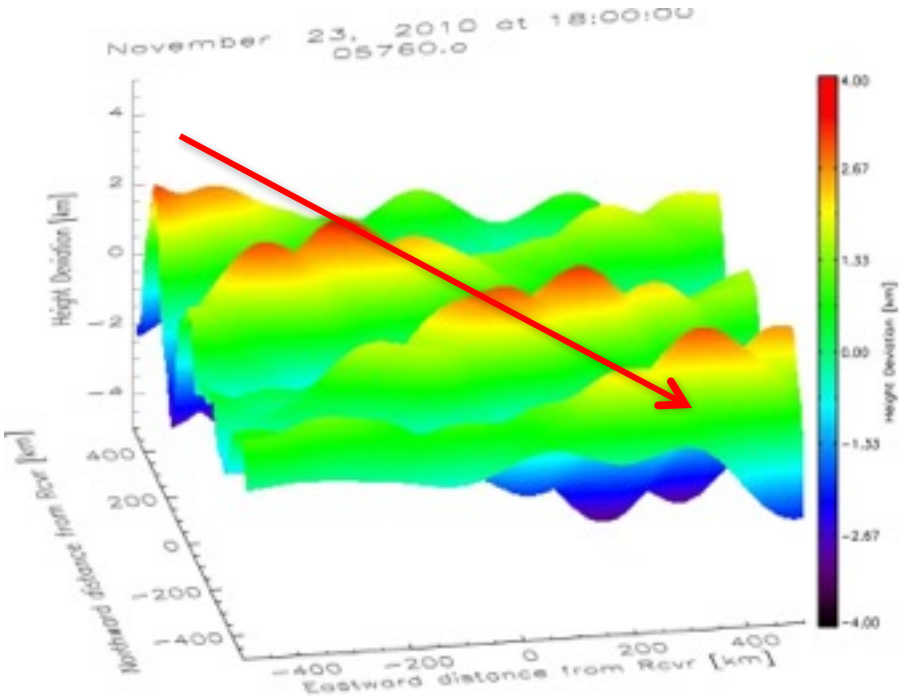


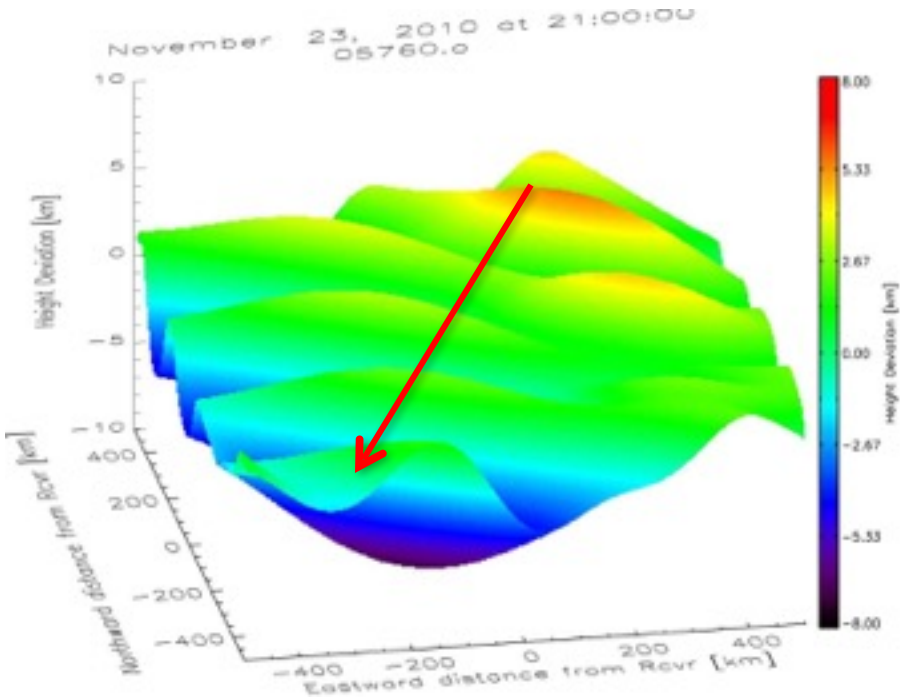
Q1) To discover the sources of wave-like plasma perturbations in the F-region ionosphere
Q2) To determine the relative role of dynamo action and more direct mechanical forcing in the formation of wave-like plasma perturbations.

Science Closure

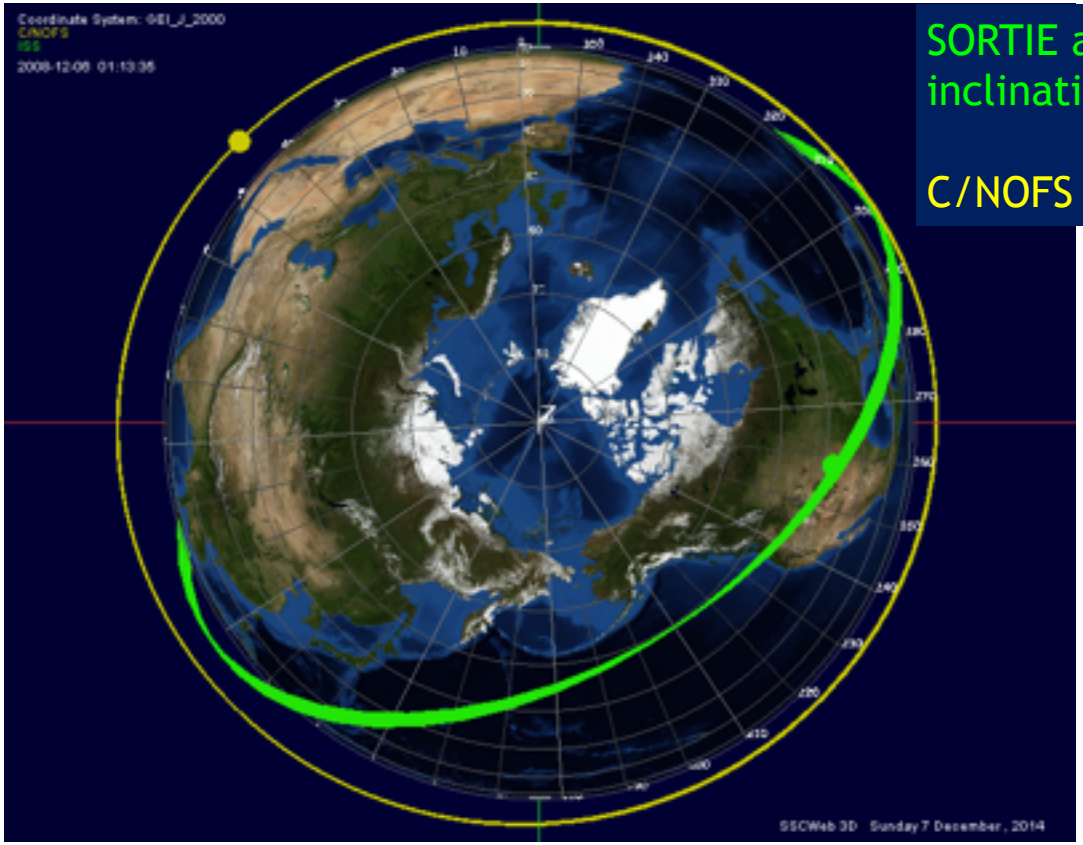
Measure phase delay between the velocity components parallel and perpendicular to the magnetic field and the plasma density perturbation.

- High-cadence plasma densities
- Vector ion drift





SORTIE vs. C/NOFS

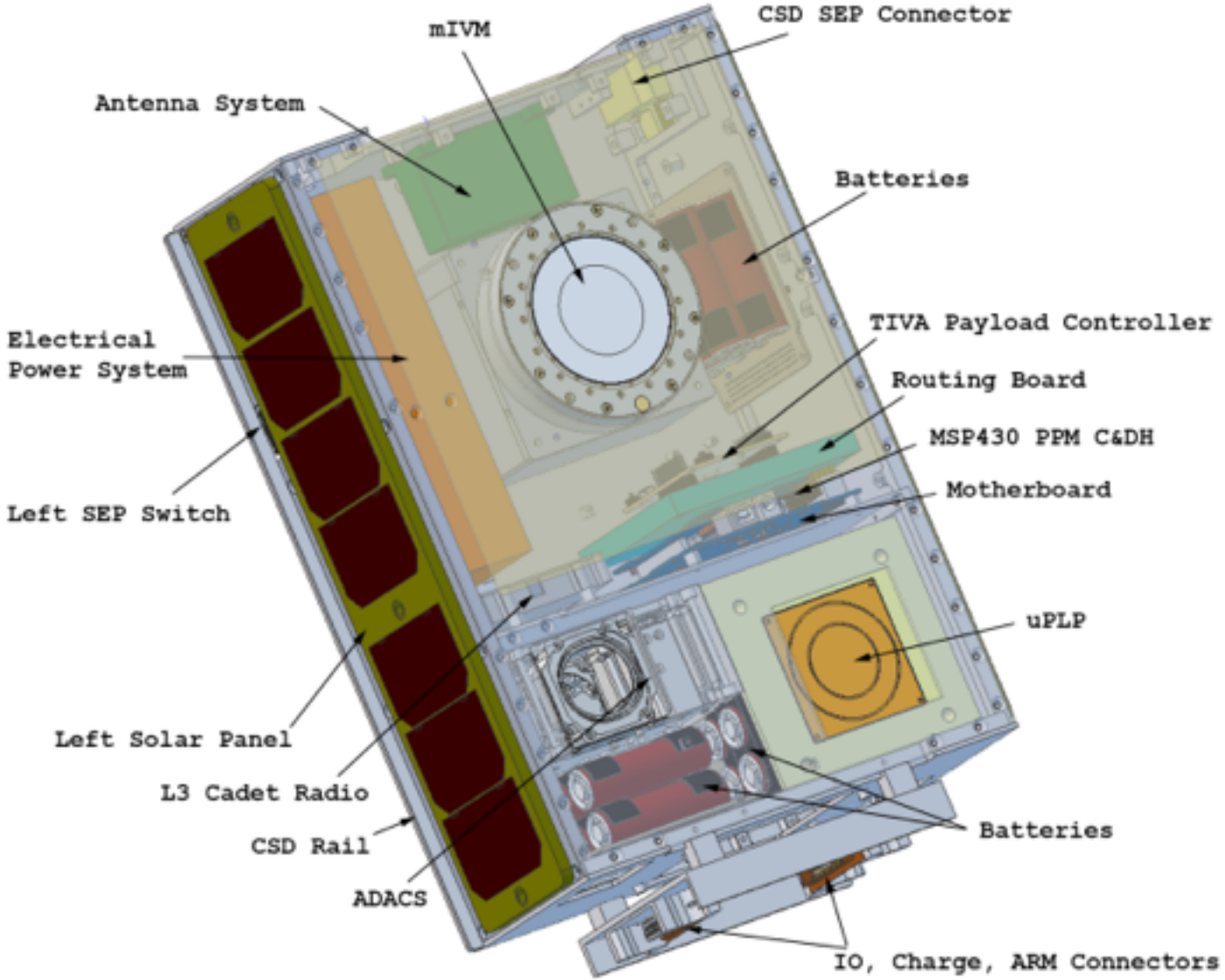


SORTIE at 52° inclination

C/NOFS orbit in 2009

- SORTIE will complement C/NOFS dataset by sampling from a different orbit
- SORTIE will provide new/continuing data now that C/NOFS has reentered
- The near-circular SORTIE orbit will provide more optimal ionospheric sampling
- SORTIE instruments: mini-IVM, micro-PLP
- C/NOFS instruments: IVM, PLP, NWM, CORISS, CERTO, VEFI
- SORTIE will complement the NASA ICON mission that will launch in 2017

System Overview



The Instruments

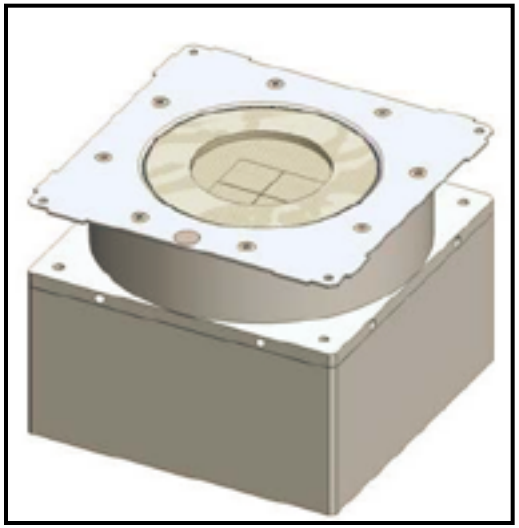
cs-IVM specifications

Parameters	Estimated Value	Parameters	Estimated Value
Mass	<750g	Voltages Required	+5VDC
Dimensions	< 98 x 98 x 75mm	FOV	±45° from edge of sensor
Power Consumption	450mW (average) 500mW (peak)	Pointing Required	+/- 0.05° (knowledge) +/- 10° (control) <0.125°/min (slew rate)

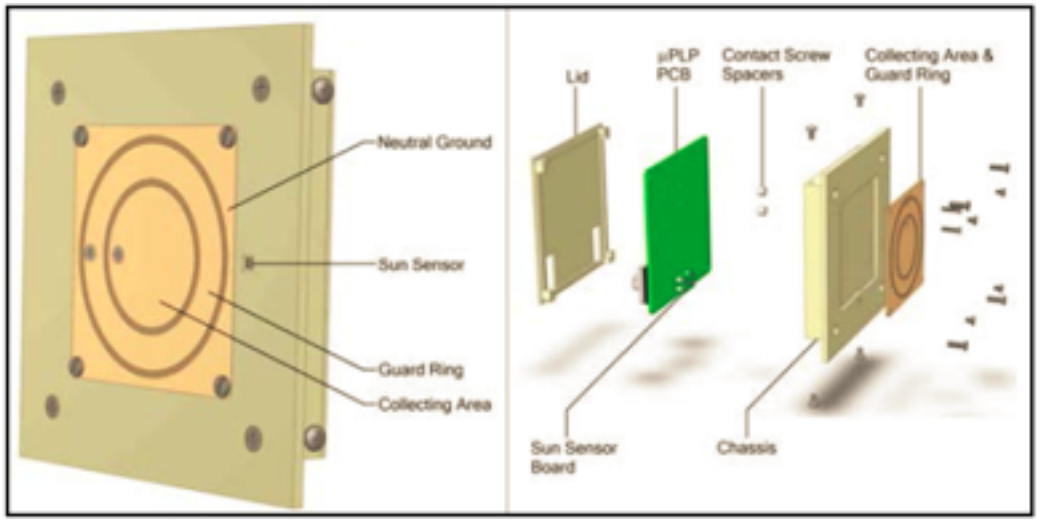
µ-PLP specifications

Parameters	Estimated Value	Parameters	Estimated Value
Mass	<300g	Voltages Required	+12VDC, +3.3VDC
Dimensions	< 90 x 85 x 25mm	FOV	±30° from edge of sensor
Power Consumption	200mW (average) 300mW (peak)	Pointing Required	+/- 5° (knowledge) +/- 10° (control)

cs-IVM

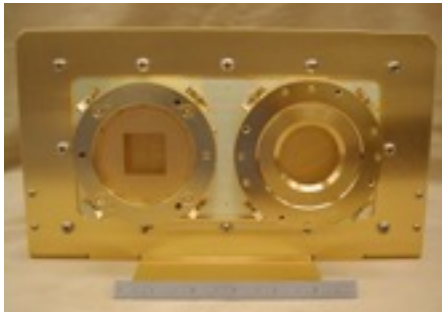


µ-PLP

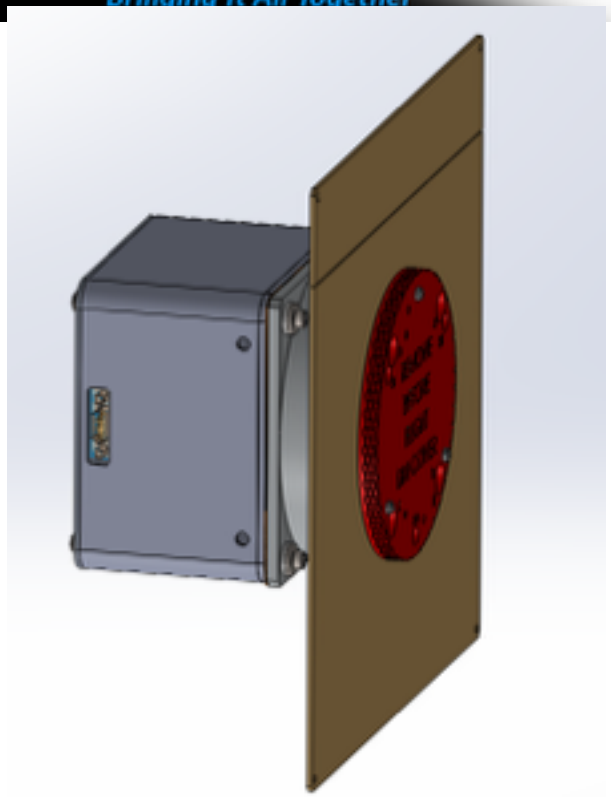


On-Board Instruments: Ion Velocity Meter (IVM)

- Developed by UTD
- Suite of Ion Potential, Drift, and Velocity



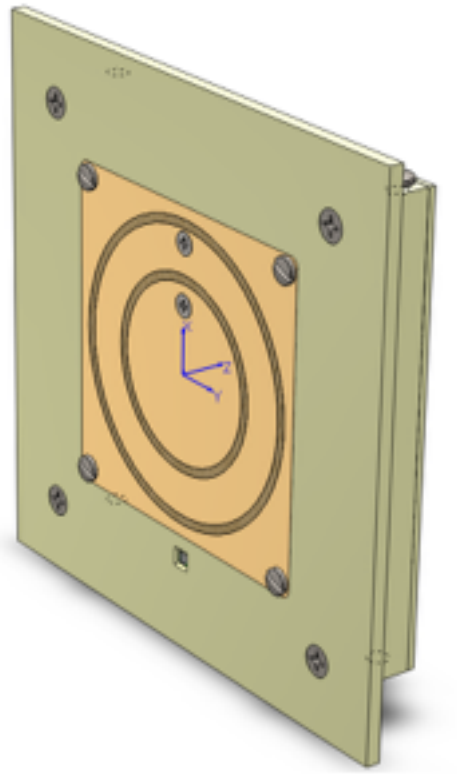
CINDI C/NOFS



Specification	Mission Requirement	Performance	Margin
Spatial Resolution	< 100 km	< 4 km	25x
Vertical Drift Range	+/- 500 m/s	+/- 1000 m/s	2x
Vertical Drift Resolution	1 m/s	0.5 m/s	2x
Accuracy/Noise	< 20 m/s (13m/s allocated)	7 m/s	1.85x

On-Board Instruments: μ Planar Langmuir Probe

- Developed by AFRL
- Planar Langmuir Probe
  - Simplified design over heritage instruments
- Measure Ionospheric plasma density fluctuations along the orbital track

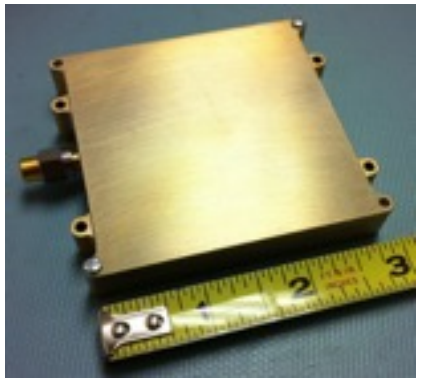


Specification	Mission Requirement / Expected Performance
Spatial Resolution	< 100 km
Range	$1x10^2$ - $1x10^7$ cm^{-3}
Resolution	10% or 100 cm^{-3}
Accuracy/Noise	10% or 100 cm^{-3}

Mission Operations Center and Ground Station

❖Science
❖ Technology
❖ Applications

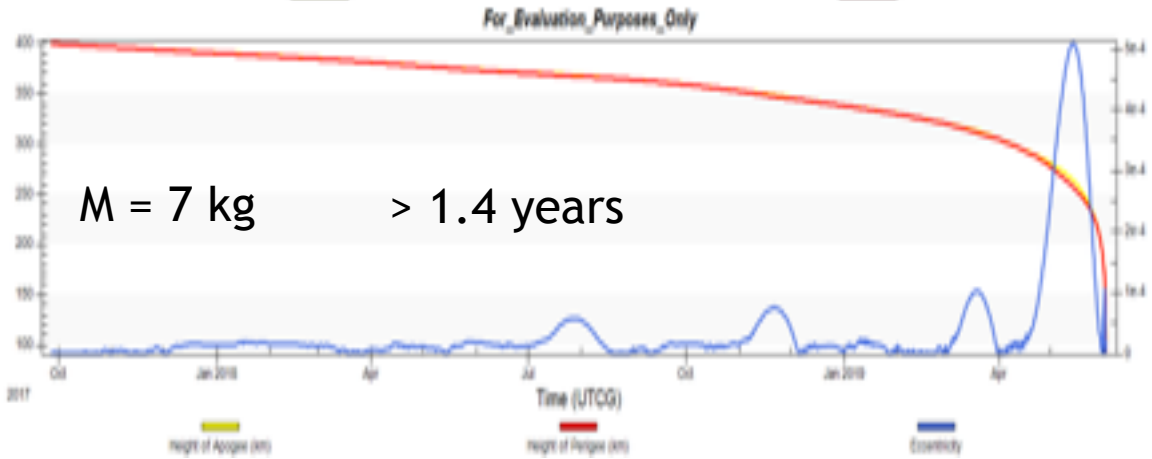
ASTRA



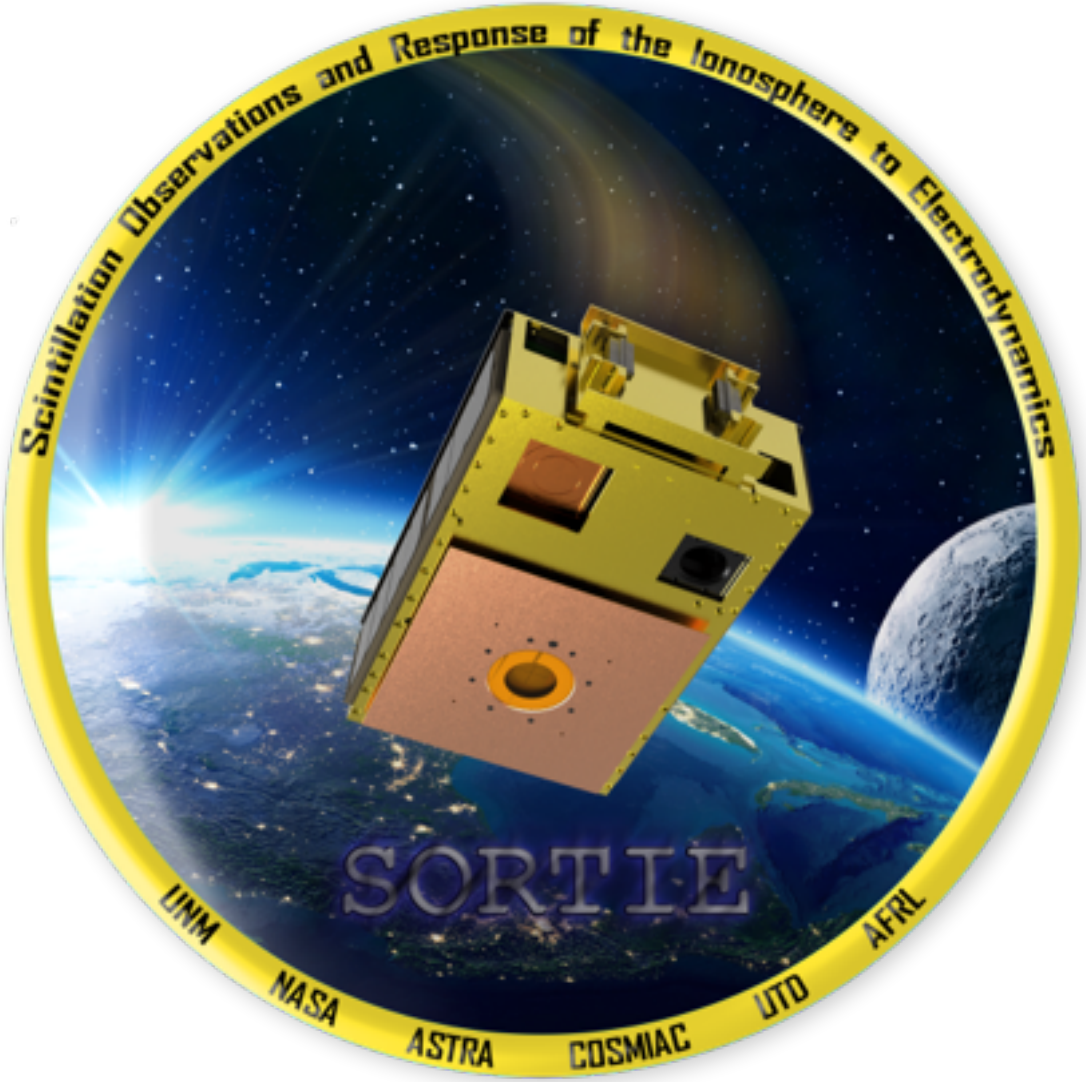
- Half-Duplex L-3 Cadet Radio
  - Downlink: 460-470 MHz band
  - 3 Mbps downlink
  - Proven on DICE mission
    - 8.4 Gigabytes of DICE mission data downloaded (> 20 Terabytes of raw data, I&Q)

SORTIE Mission Lifetime / Orbit Decay Analysis

Mission	Altitude	Inclination	Alignment	Type	Launch
Design Ref: Primary	400 km	51.65 °, 0 RAAN	Geodetic Z (J2000 Z)	ISS Orbit	Sept 2017



Questions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SORTIE
UNM
NASA
ASTRA
COSMIAC
UTD
AFRL

Data Sharing

- Data and results will be available via the ASTRA web-site (www.astraspace.net)

- This information will include a description of the physics being investigated, and the new scientific results obtained from the proposed research

- ASTRA freely distributes model results and data via ftp to the scientific community for further use in their research

- NASA also has data hosting facilities that could be used for data archiving and distribution. These include the CDAWeb and NSSDC, and these options will be investigated.

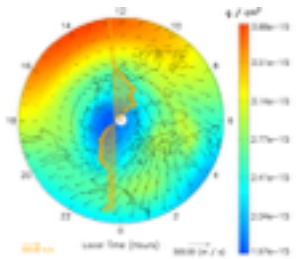
ASTRA: Overview

❖Science
❖ Technology
❖ Applications
Bringing It All Together

ASTRA

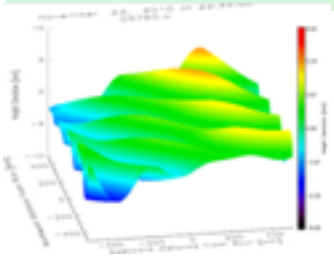
Modeling

- Physics-Based Modeling (TIMEGCM)
- Real-Time Specification of Ionosphere/ Thermosphere



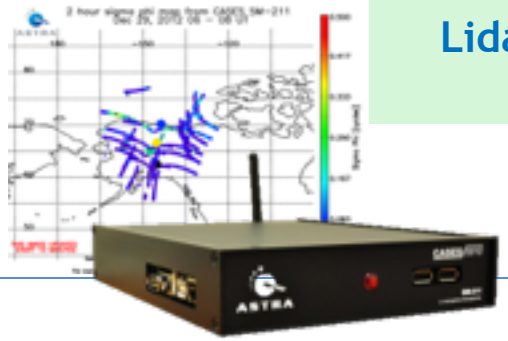
Data Assimilation

- High-latitude Electrodynamics
- Global Ionosphere
- Thermospheric Neutral Density
- Satellite Drag & Ballistic Coefficients



Data Services

- Space Based Data
- Ground Based Data
- Forensic Space Weather Analysis
- Satellite Aerodynamics



Ground-based Instrument Development

- GPS-based Space Weather Monitor
- E-fields and Magnetometers
- Low Power Ionospheric Sounder
- HF TID Mapper
- Lidar Systems

Space Systems

CubeSat Missions
- NSF: DICE & LAICE
- AF: DIME, SIPS & TSS
- NASA: SORTIE & MiRaTa

Plug-N-Play Avionics

CubeSat Instruments
- Scanning UV Photometer
- E-field Double Probe
- RF Waves & Sounder
- Wind Profiler
- GPS-based Space Weather Monitor
- Magnetometer & Langmuir Probe

Hosted Payloads

Celebrating our 10th Anniversary

ASTRA Mission Competencies

ASTRA Core Competencies for Satellite Missions

- Mission Development / Science
- Mission Design
- Mission Management
- Mission Systems Engineering
- Instrument Development
- Algorithm Development
- Data Analysis and Interpretation
- Product Development

ASTRA staff have more than 70 decades of combined space flight & space science heritage, and have developed, tested, and flown systems on more than 20 orbital and sub-orbital space missions.

Selected CubeSat Missions

❖Science
❖ Technology
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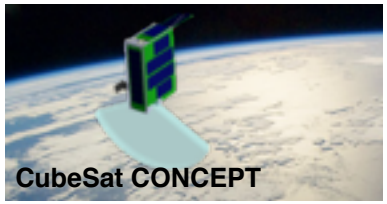
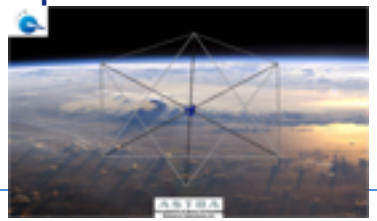
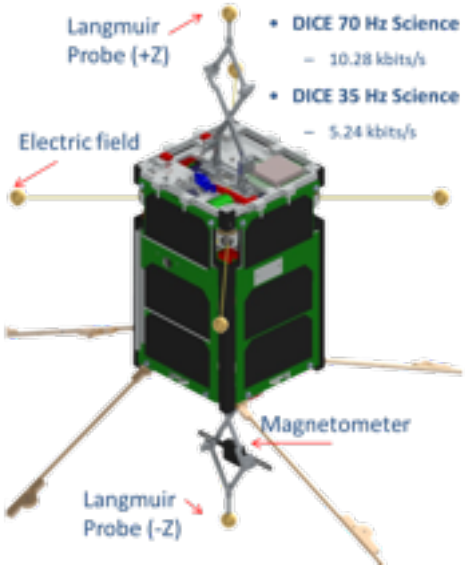
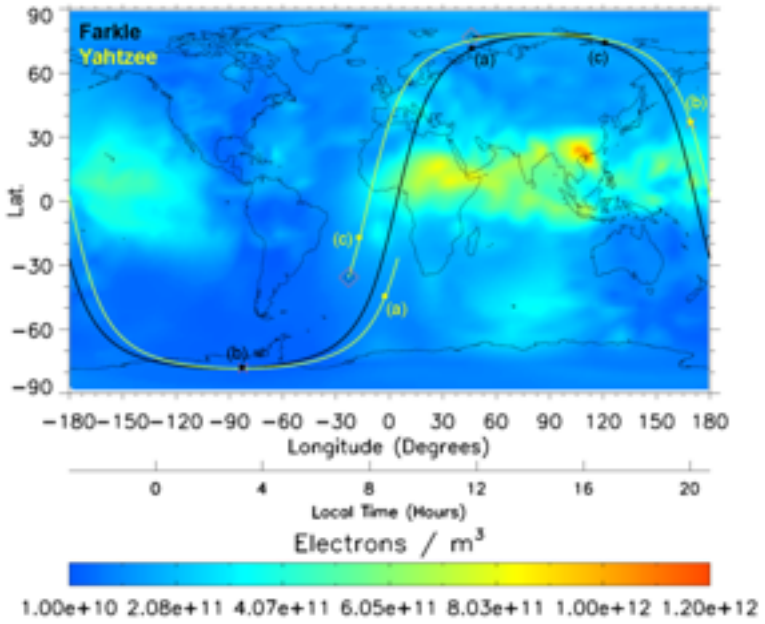
ASTRA

Mission	Launch	Instruments	Description
DIME **Double-probe Instrumentation for Measuring Electric-fields** 	**Est. 2017** **Status:** **Entering I&T phase**	• **Two Langmuir probes** to measure in-situ ionospheric plasma densities. • **Science and attitude magnetometers** • **Four electric field probes** on 3.5-meter cable booms	**Currently being built for the Air Force.** A CubeSat solution for monitoring electric fields in Low-Earth Orbit implementing lessons-learned from on-orbit experience with DICE. **Form: 1.5 U**
SIPS **Scanning Imaging Photometer Systems (UV Imager)** 	**Est. 2018** **Status:** **UV Detector** • Built and tested, including mechanical/thermal • Sensor flown on the SENSE mission **Front End optics** • Scan mirror built, & tested: mechanical/thermal	**Combination:** • **UV Detector (photometer)** • **Scanning mirror** Higher SNR than DMSP SSUSI instrument (clearer features) Viable SSUSI replacement (lower SWaP, and cost by 10x)	**Low cost and versatile sensor for UV remote sensing of the ionosphere** Capable of providing night-time images of the ionosphere enabling almost continuous monitoring of the night-side ionosphere. Resolves ionospheric structures at 1 vertical TEC unit (better than GPS TEC) **Form: 6U**
Topside Sounder 	**Est. 2018** **Status: Sensor completed – Q4FY15 demonstration for AF**	• **Large deployable HF antennas** • **Miniaturized ultrasensitive receivers**	**Low power FMCW HF Sounding instrument to make topside measurements of the ionosphere from a CubeSat platform.** **Form: 12U**

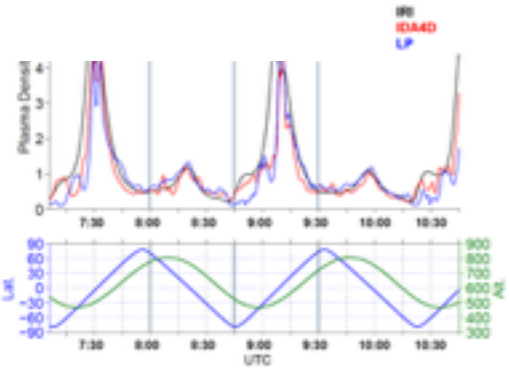
Instrumentation: LP/E-FIELD/ Mag
Observations: E, B, N_e, N_i, T_e





Sensor SWaP	
Volume (U)	0.4
Mass (g)	350
Power (mWDC)	520

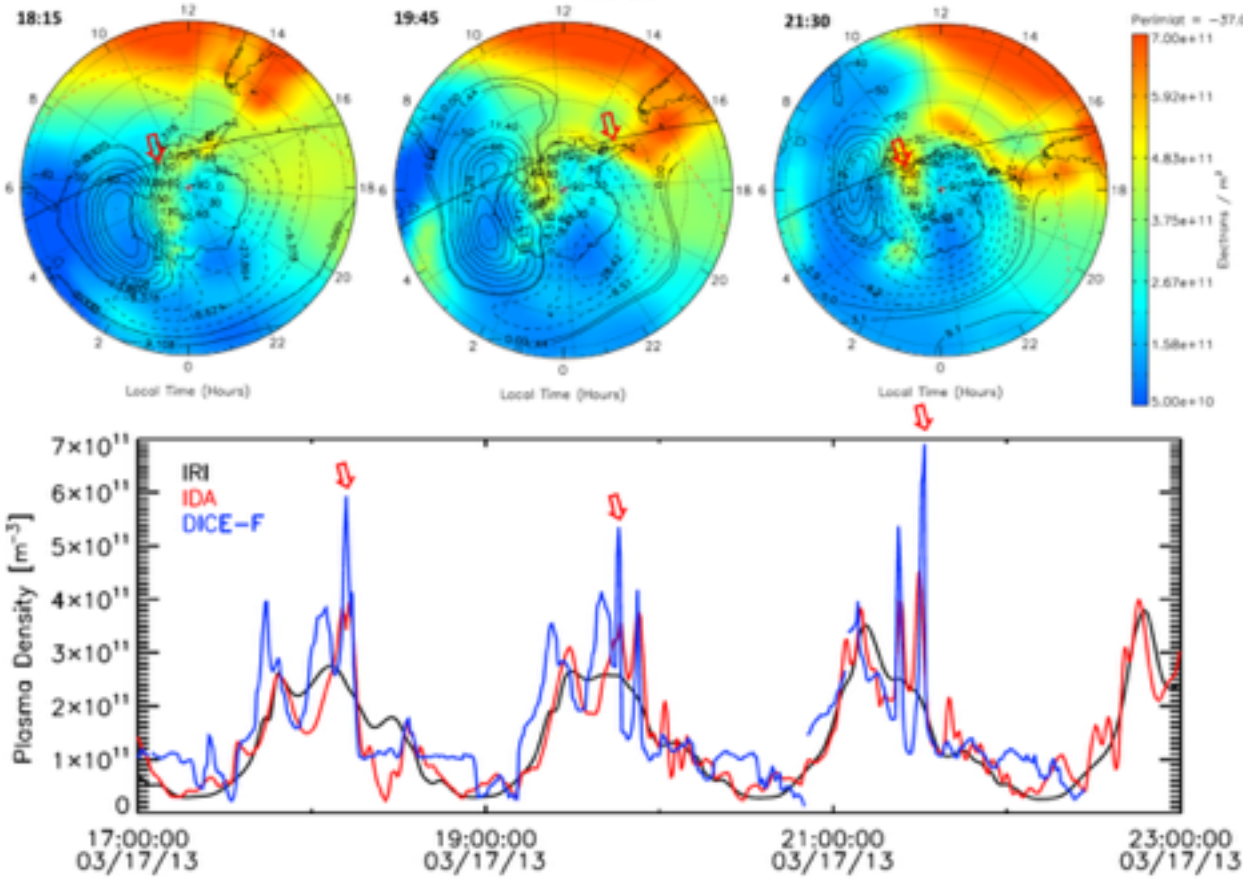
YAHTZEE
FARKLE



DICE: Data Analysis and Dissemination

ASTRA: Measurement to information

Assimilating data into models for operational products



Above: DICE plasma density observations compared with IDA4D assimilation of the south polar ionosphere. Note that the enhanced densities observed by DICE (red arrows in the bottom plot) correspond to when the DICE satellite passes through a tongue of ionization during successive passes (red arrows).

SORTIE at a Glance

- Customer: NASA (HTIDES)
- Broader impact: scintillation
- Motivation: better understanding of the distribution of initial wave-like plasma perturbations and the conditions under which they can be related to intense plasma instabilities
- ASTRA is the PI institution (G. Crowley, C. Fish, M. Pilinski)
- Teaming with:
  - UT Dallas: providing mini Ion drift meter
    - Rod Heelis
    - Russel Stoneback
  - AFRL: providing micro planar Langmuir probe and GFE XaCT system
    - Cheryl Huang
    - Patrick Roddy
    - James Lyke
    - Louise Gentile
  - Boston College: modeling support
    - John Retterer
  - COSMIAC: bus integrator
    - Alonzo Vera
    - Craig Kief
- Mission Completed by October 2018 (launch in last quarter of 2017)

Apex height-longitude sampling

C/NOFS, 400x850km, *i*=13° SORTIE, 406x416km, *i*=13° SORTIE, 406x416km, *i*=52°