SORTIE

Scintillation Observations and Response of The Ionosphere to Electrodynamics

30th Annual AIAA/USU Conference on Small Satellites
Logan, UT
Tuesday, 8/9/2016

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ASTRA: Overview

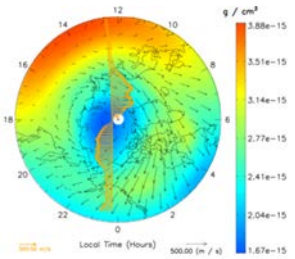
❖Science
❖ Technology
❖ Applications
Bringing It All Together

ASTRA

Modeling

Physics-Based Modeling (TIMEGCM)

Real-Time Specification of Ionosphere/ Thermosphere



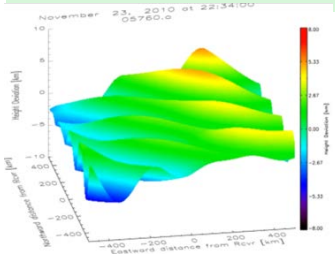
Data Assimilation

High-latitude Electrodynamics

Global Ionosphere

Thermospheric Neutral Density

Satellite Drag & Ballistic Coefficients



Data & Eng. Services

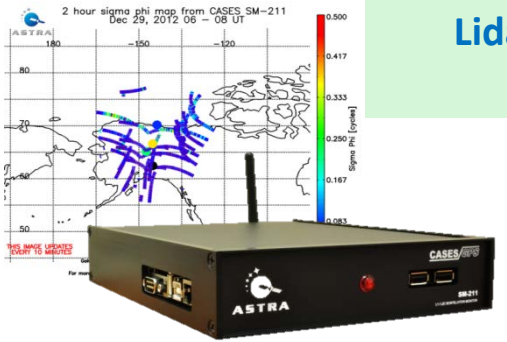
Space Based Data

Ground Based Data

Forensic Space Weather Analysis

Spacecraft Modeling

Systems Engineering



Ground-based Instrument Development

GPS-based Space Weather Monitor

E-fields and Magnetometers

Low Power Ionospheric Sounder

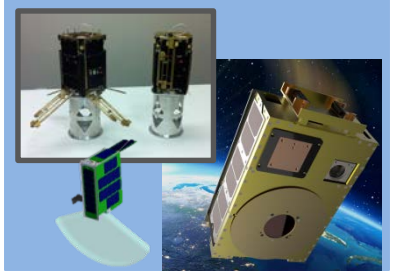
HF TID Mapper

Lidar Systems

COLORADO
COMPANIES TO WATCH
2016 WINNER

Space Systems

CubeSat Missions



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

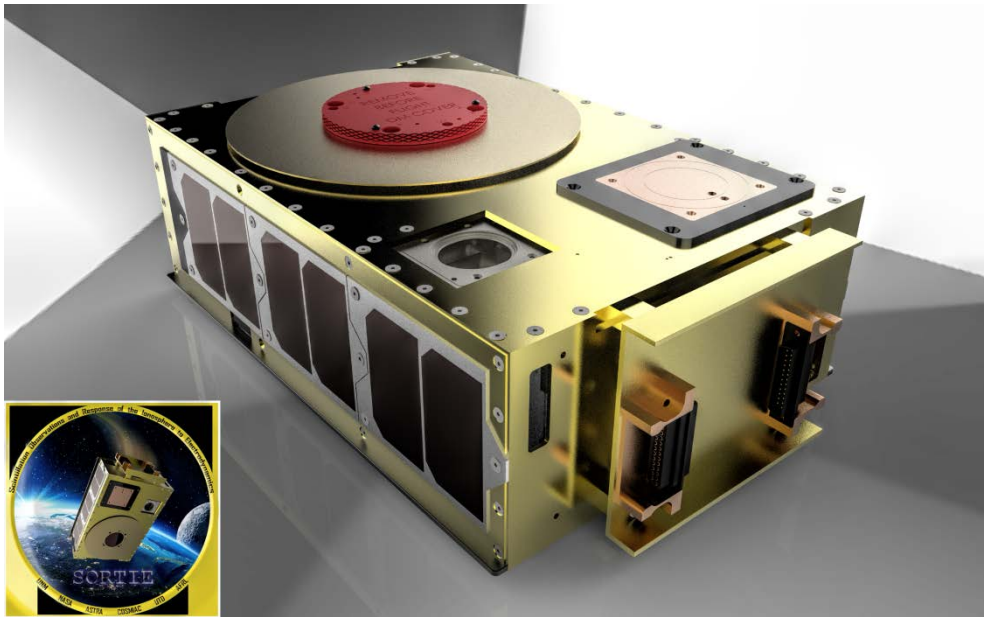
Celebrating our 11th Anniversary

SORTIE Mission Overview

❖Science
❖ Technology
❖ Applications
Bringing It All Together

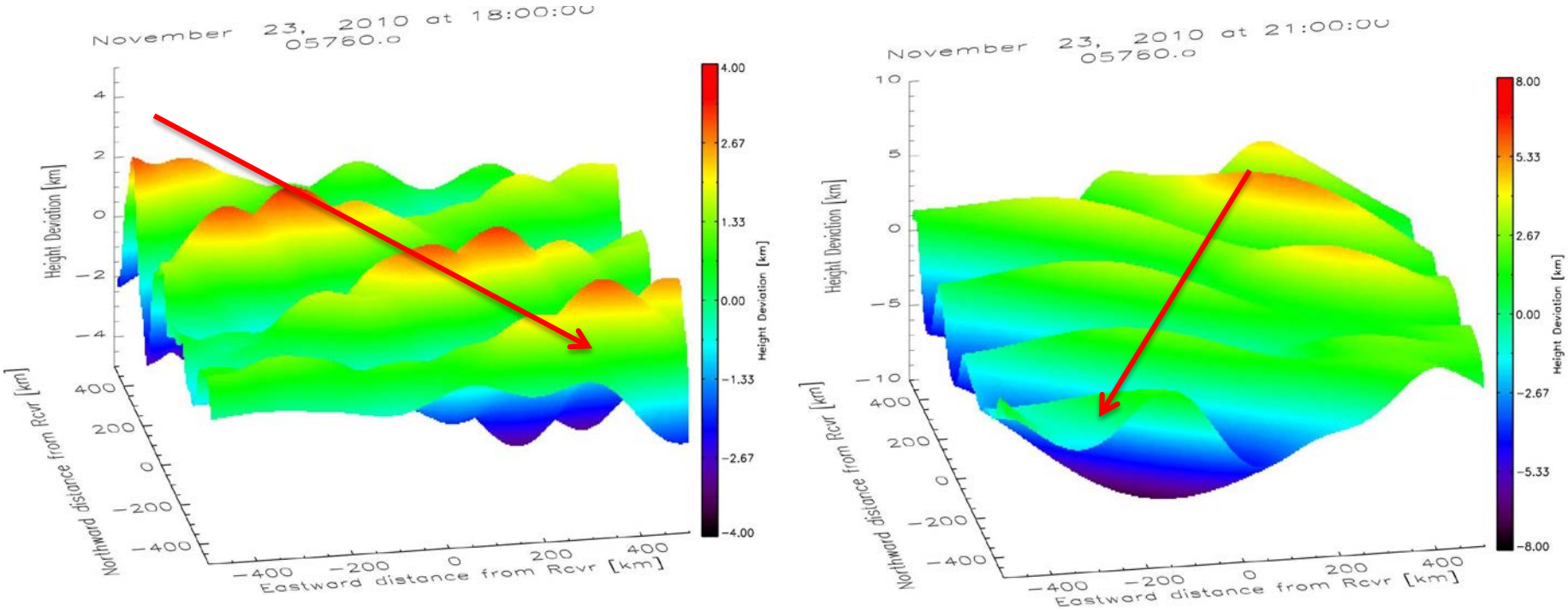
ASTRA

- 6U CubeSat Mission
- Team Members:
  - NASA
  - ASTRA
  - AFRL
  - UTD
  - COSMIAC
  - Boston College
- Slated to launch late Fall 2017 (CSLI opportunity for ISS Launch)
  - October ‘17 delivery, December ‘17 launch
  - Provide overlap with NASA’s ICON mission
- CDR complete
- 1 Year of on-orbit lifetime

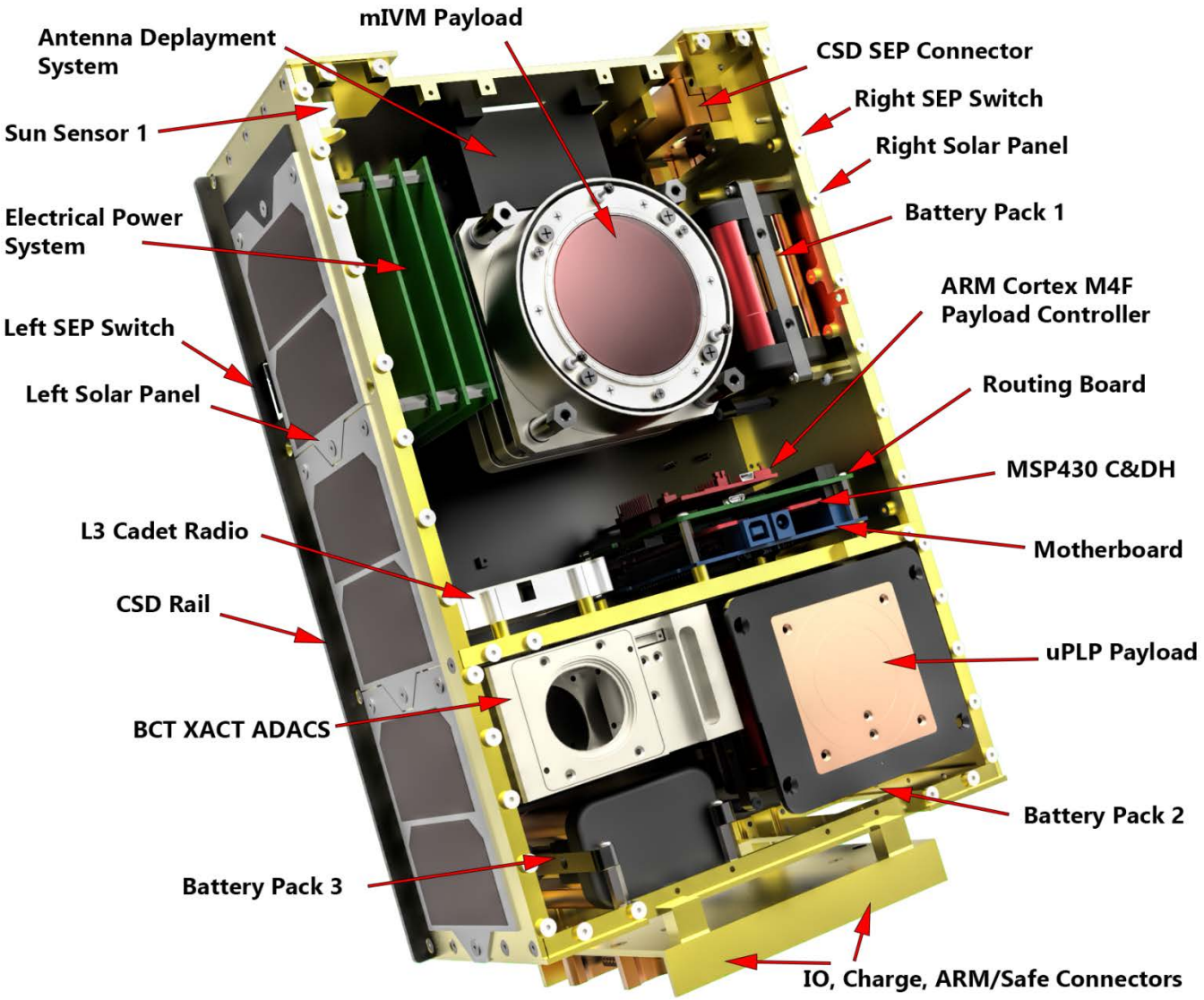


Science Goals

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.



System Overview



The Instruments

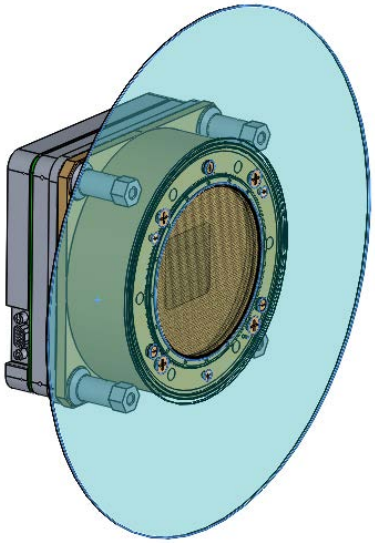
cs-IVM specifications

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)

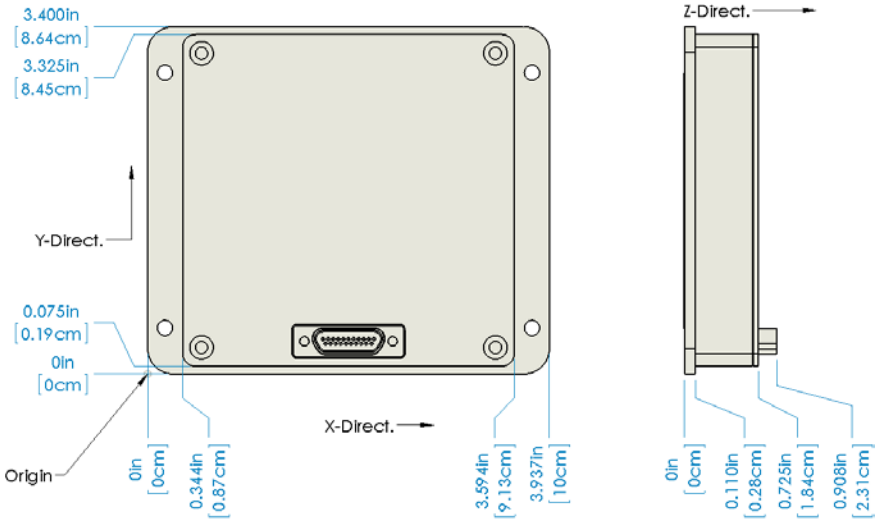
µ-PLP specifications

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

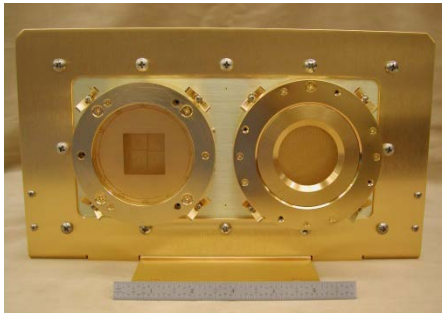


µ-PLP

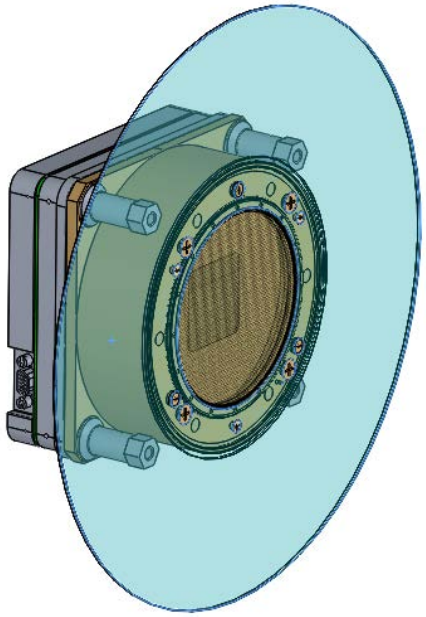


Instruments: Ion Velocity Meter (IVM)

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



CINDI C/NOFS

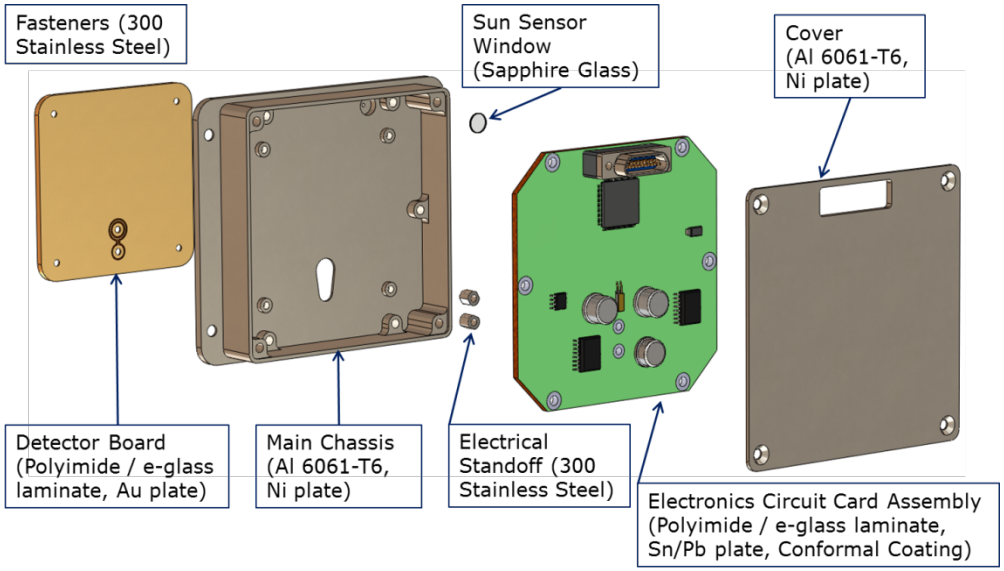


SORTIE

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

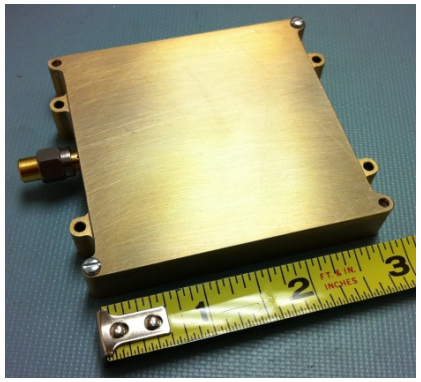
Instruments: μ Planar Langmuir Probe

- Developed by AFRL
- Planar Langmuir Probe
  - Simplified design over heritage instruments
- Measures 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}

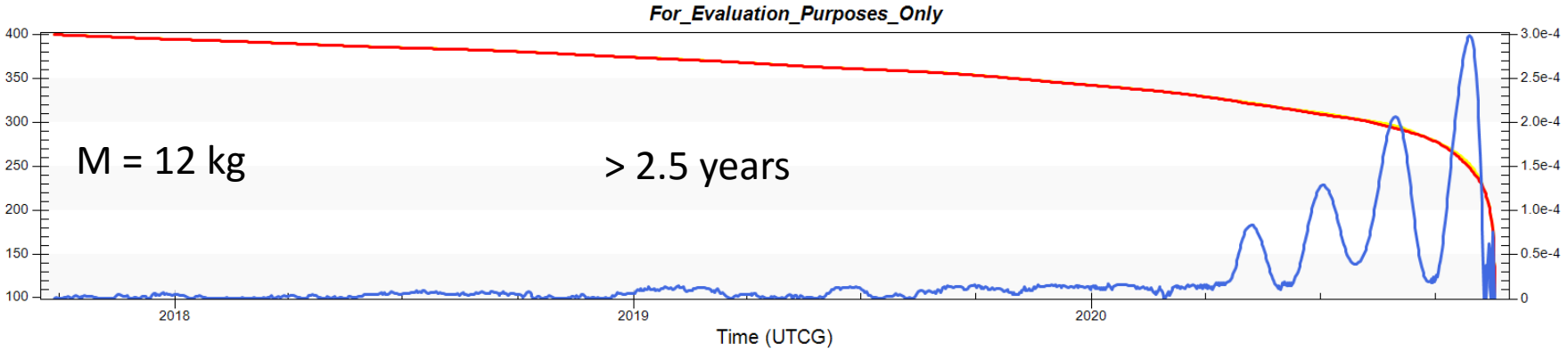
Mission Operations Center and Ground Station

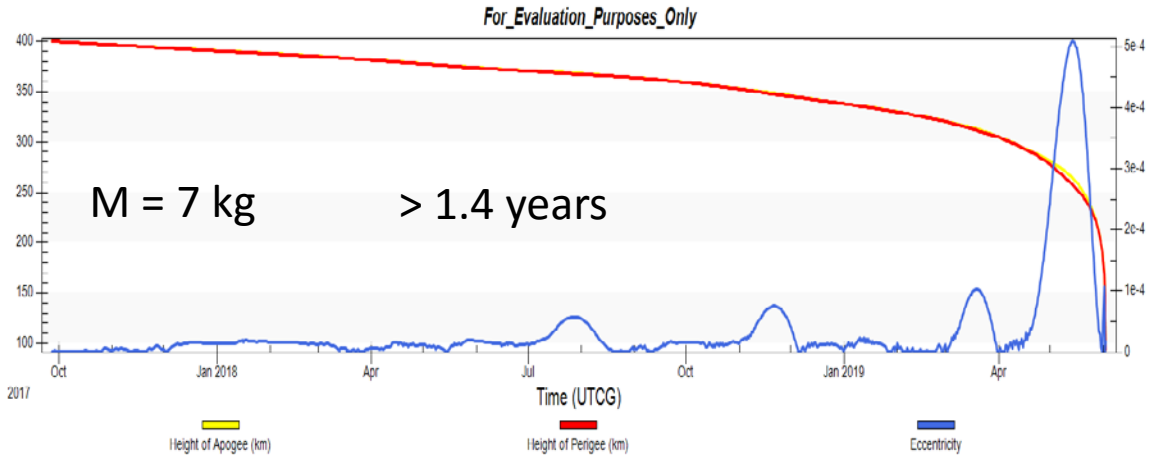


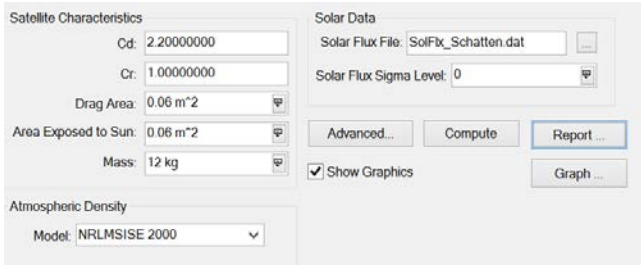
- Half-Duplex L-3 Cadet Radio
  - Downlink: 460-470 MHz band
  - 3 Mbps downlink
  - Proven on DICE mission
    - 8.4 Gigabytes of DICE mission data downloaded (> 20 Terabytes of raw data, I&Q)

SORTIE Mission Lifetime / Orbit Decay Analysis

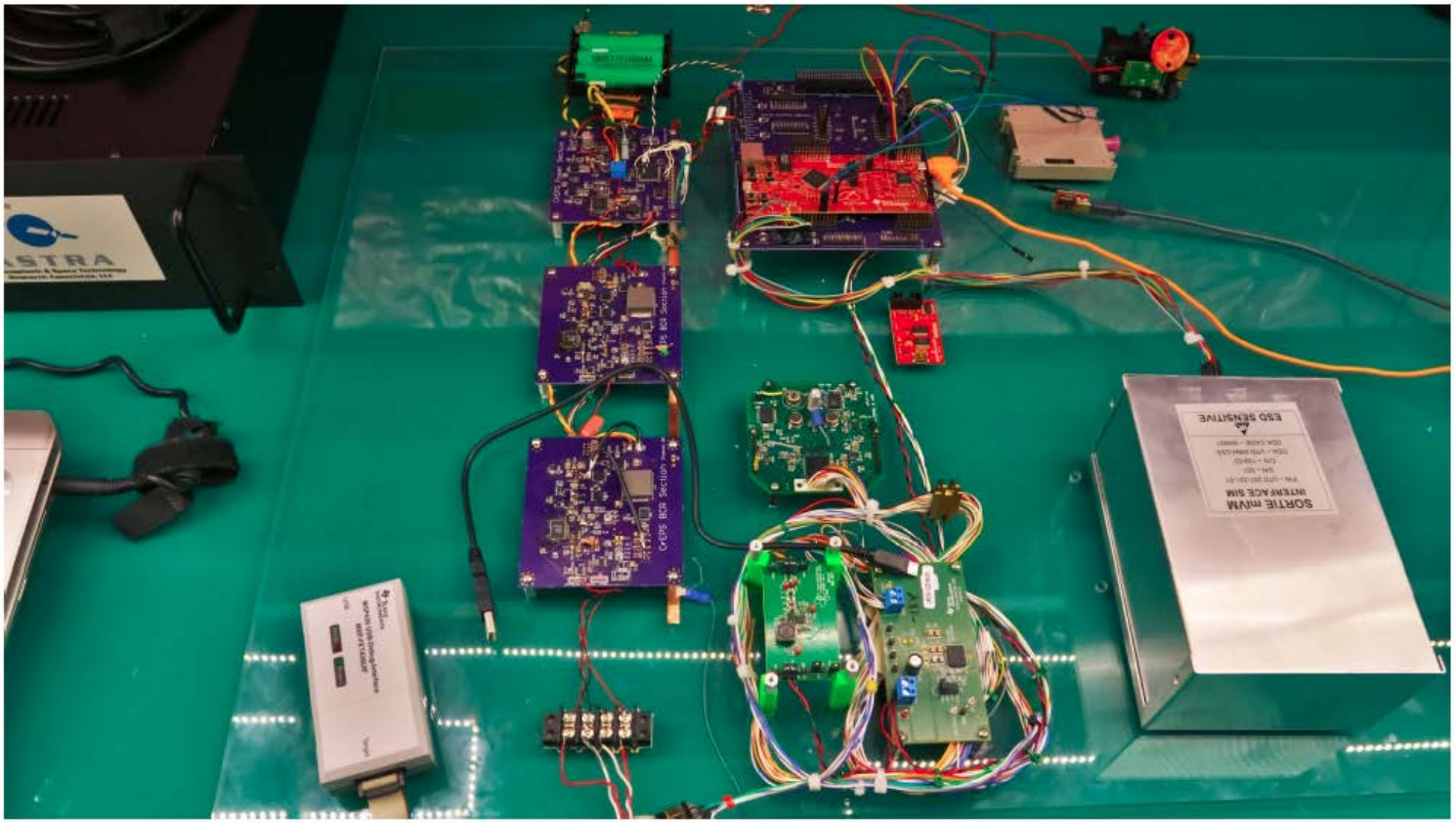
Mission	Altitude	Inclination	Alignment	Type	Launch
Design Ref: Primary	400 km	51.65 °, 0 RAAN	Geodetic Z (J2000 Z)	ISS Orbit	Sept 2017



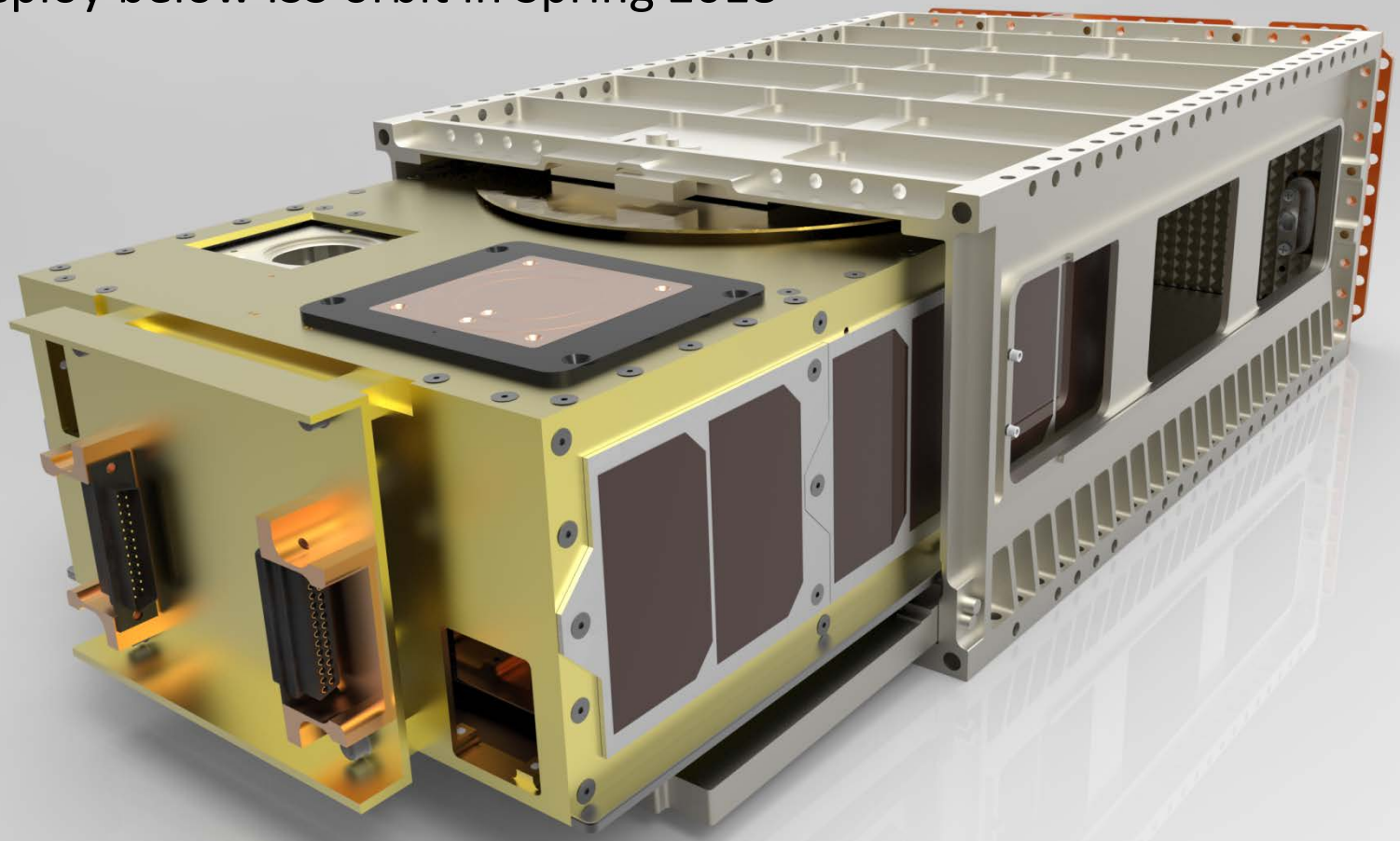




FlatSat Testing



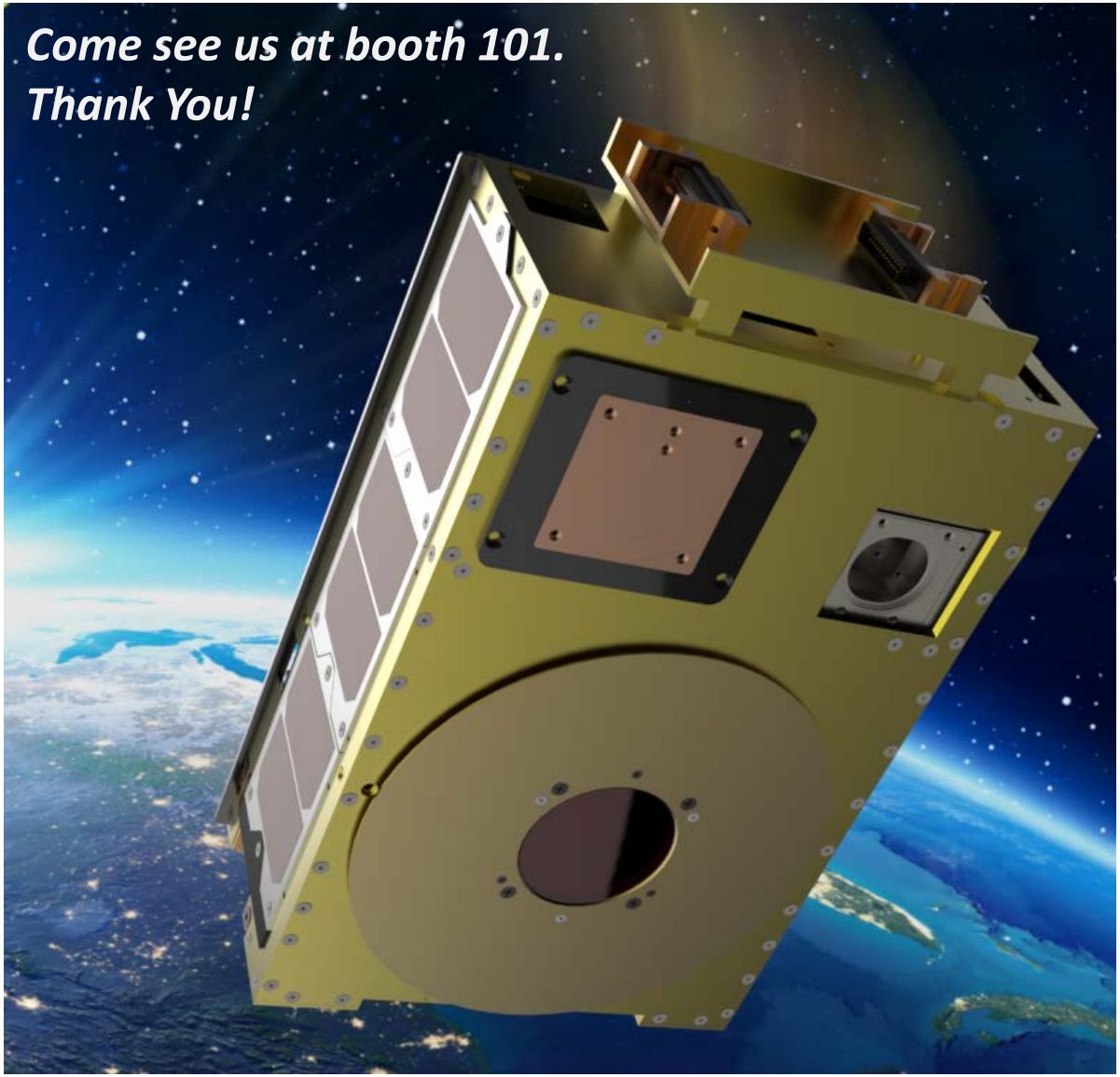
- Flight to ISS in Fall 2017
- 6-9 month wait at ISS
- Deploy below ISS orbit in Spring 2018



Questions?

❖Science
❖ Technology
❖ Applications
Bringing It All Together

ASTRA



Backup Slides

- 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 Mission Competencies

ASTRA Core Competencies for Satellite Missions

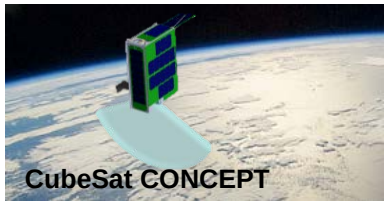
- **Mission Development / Science**
- **Mission Design**
- **Mission Management**
- **Mission Systems Engineering**
- **Instrument Development**
- **Algorithm Development**
- **Data Analysis and Interpretation**
- **Product Development**

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

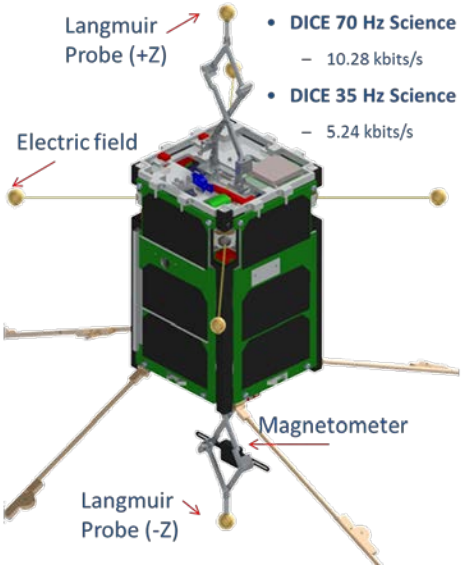
❖Science
❖ Technology
❖ Applications
Bringing It All Together

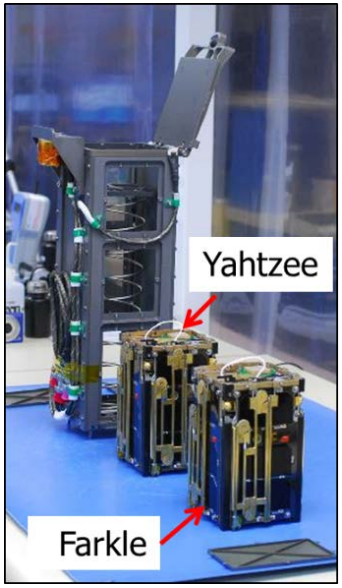
ASTRA

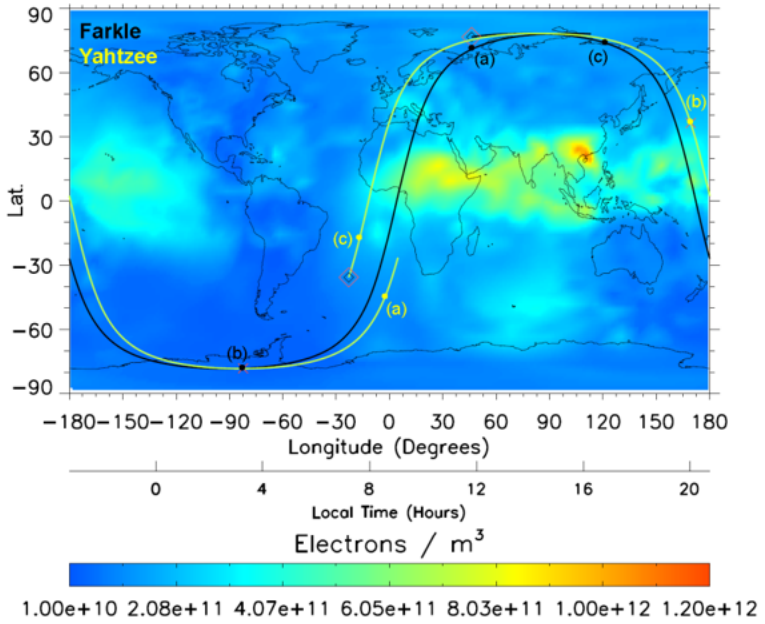
Mission	Launch	Instruments	Description
DIME **Double-probe Instrumentation for Measuring Electric-fields** 	**Est. 2017** **Status:** **Entering I&T phase**	• **Two Langmuir probes** to measure in-situ ionospheric plasma densities. • **Science and attitude magnetometers** • **Four electric field probes** 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**

Electric Field Constellation Pathfinder: DICE

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

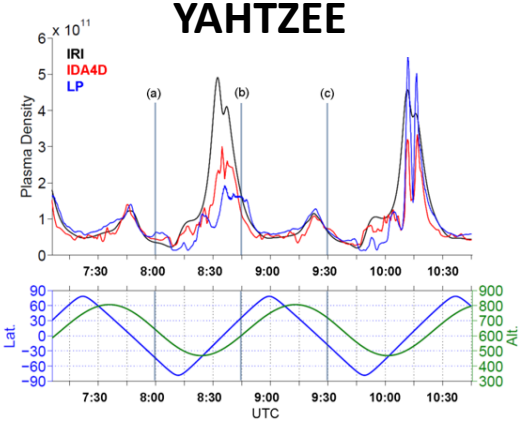




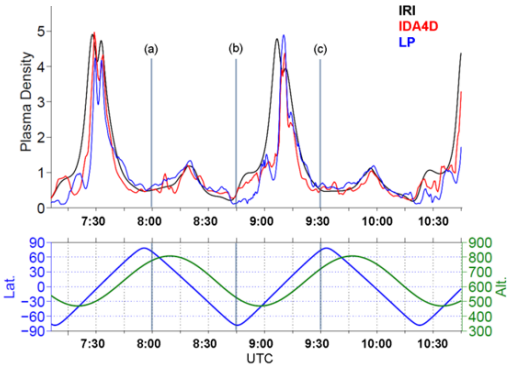


Sensor SWaP	
Volume (U)	0.4
Mass (g)	350
Power (mWDC)	520

YAHTZEE

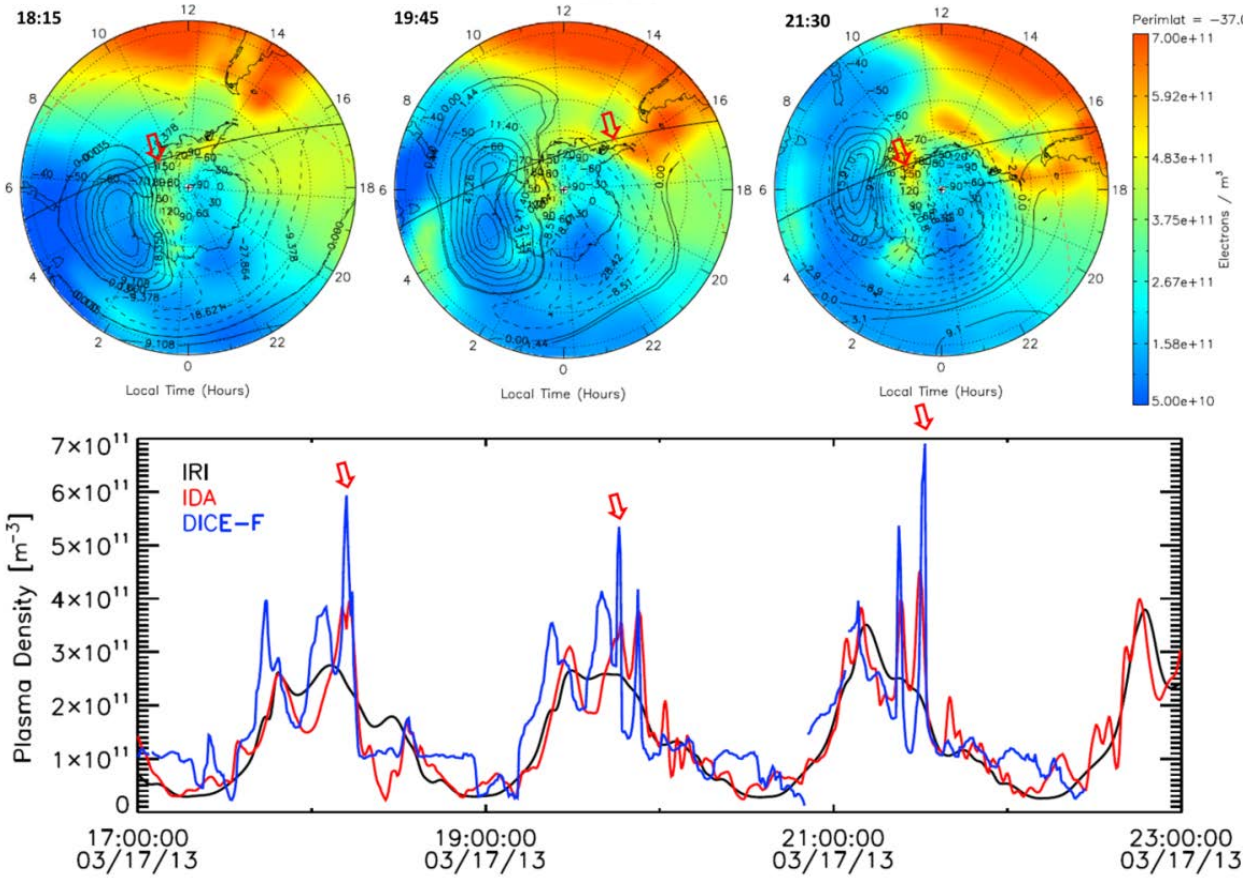


FARKLE



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

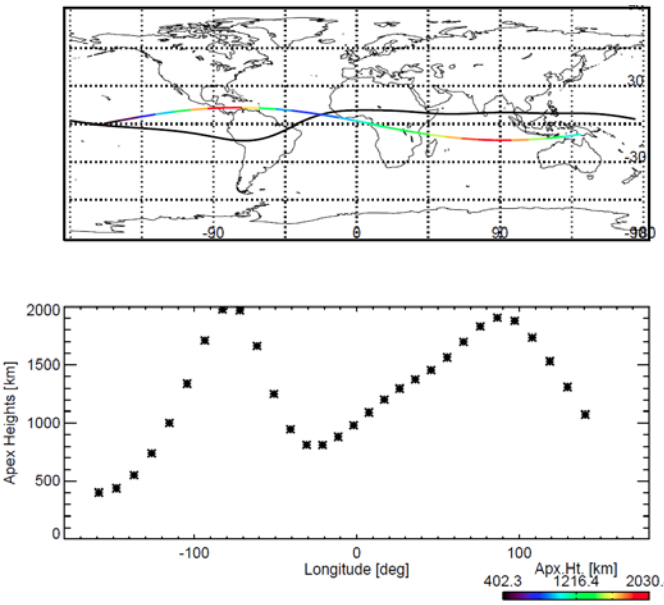
❖Science
❖ Technology
❖ Applications
Bringing It All Together

ASTRA

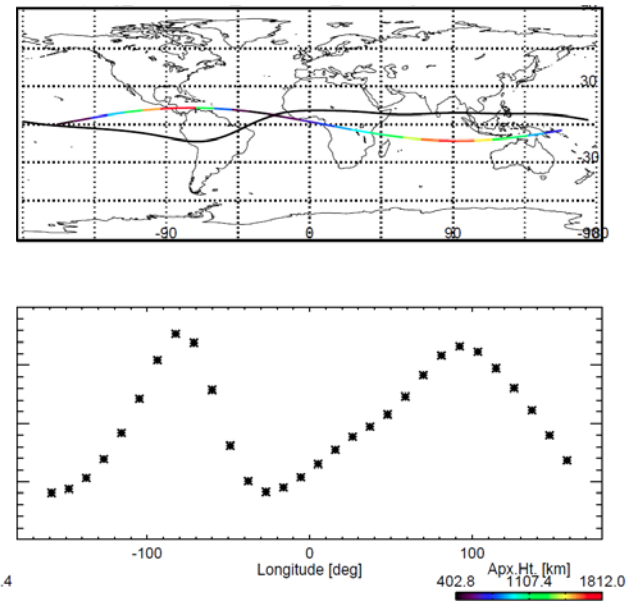
- Customer: NASA (HTIDES)
- Broader impact: scintillation
- Motivation: better understanding of the distribution of initial wave-like plasma perturbations and the conditions under which they can be related to intense plasma instabilities
- ASTRA is the PI institution (G. Crowley, C. Fish, M. Pilinski)
- 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

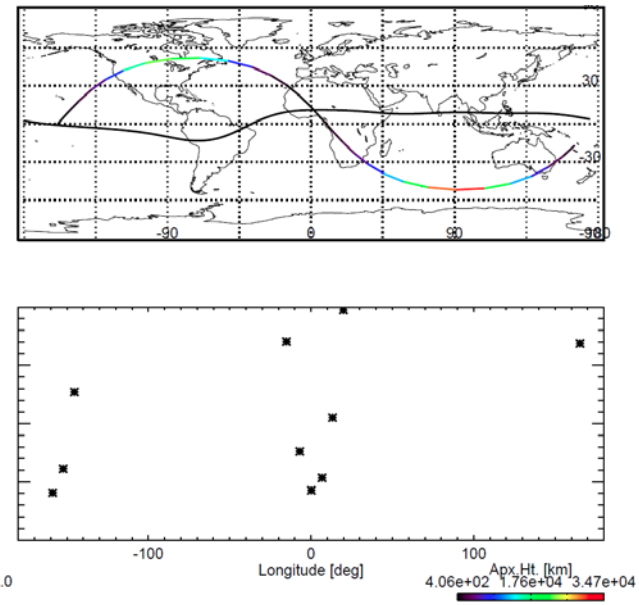
C/NOFS, 400x850km, *i*=13°



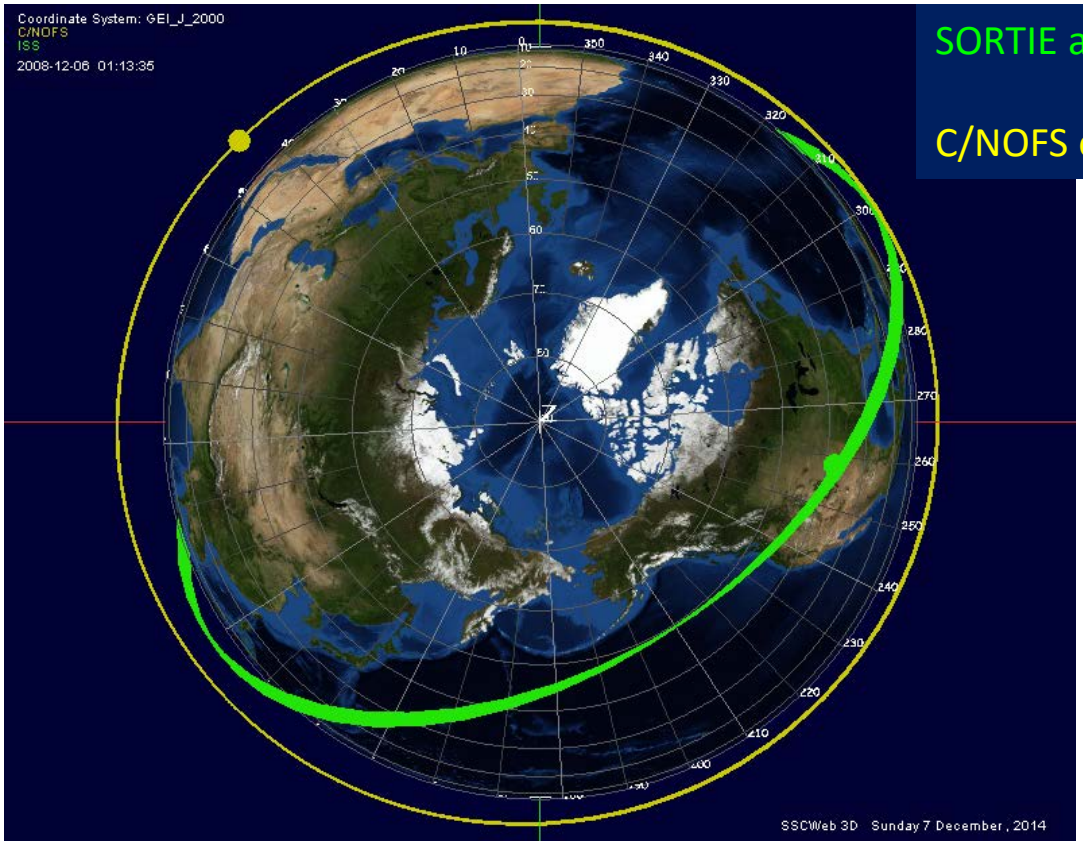
SORTIE, 406x416km, *i*=13°



SORTIE, 406x416km, *i*=52°



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