SPORT

The Scintillation Prediction Observations Research Task Formulation Meeting

April 17, 2017

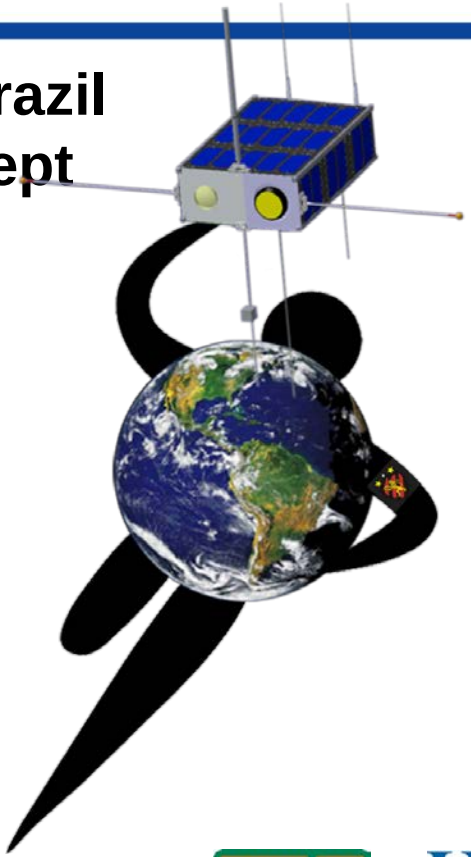
INPE, São José dos Campos

Agenda

Time	duration	
		Coffee
9:00	0:30	*Intro and welcome – INPE/ITA*
9:30	0:15	*Science Overview – Spann/Krause/Swenson*
9:45	0:20	*Current Status – NASA Spann, ITA Loures*
10:05	0:30	*Roles & Responsibilites - Spann/Nash-Stevenson*
10:35	0:30	*Review Schedule and Mission Milestones - Nash–Stevenson*
11:05	0:15	*Break*
11:20	0:20	*Science Plan – Krause*
11:40	0:15	*Mission Requirements - Eberly/Durão*
11:55	0:15	*Magnetometer – Le*
12:10	0:15	*SPORT Formulation M*
12:25	1:30	*Lunch - cafeteria*
13:55	0:15	*Langmuir and Impeadance Probes - Swenson*
14:10	0:15	*IVM Drift Meter - Heelis*
14:25	0:20	*S/C Instrument interfaces and plans to address – Loures*
14:45	0:20	*Integration and Test plan – Lídia/Jose Sergio and Eberly*
15:05	0:15	*Ground Network Observatory integration into SPORT – Joaquim*
15:20	0:15	*Break*
15:35	0:20	*Mission Operations plan and status – Fátima*
15:55	0:30	*Near-term issues – Nash/Spann/Loures*
16:25	1:00	*Discussion about other possible cubesat applications in space sciences - Durão/all*
17:25		

SPORT

- **Joint United States / Brazil Science Mission Concept**



- **United States**
  - – Science Instruments
- **Brazil**
  - – Spacecraft
  - – Operations

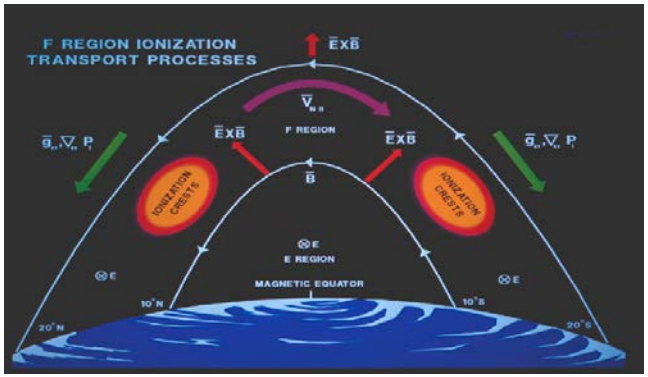
Joint Science Data Analysis

Science Overview

J. Spann. L. Krause, C. Swenson

Science

- **The equatorial ionization anomalies**



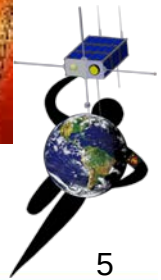
Bela Fejer, The Equatorial Ionosphere: A Tutorial
CEDAR Meeting, Seattle Washington, 2015

- **Plasma Bubbles**

GUVI (Same Local Time, Different Longitudes)

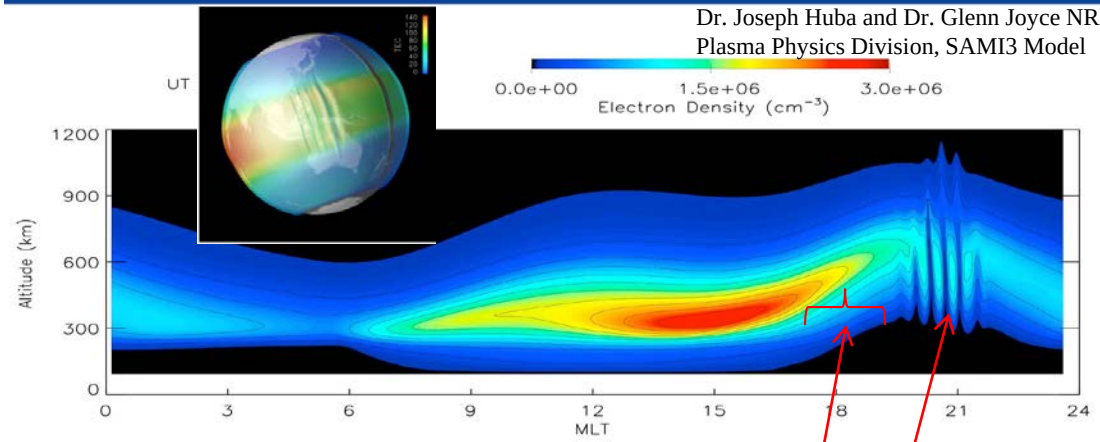
Why do bubbles form and sometimes not at Different Longitudes?

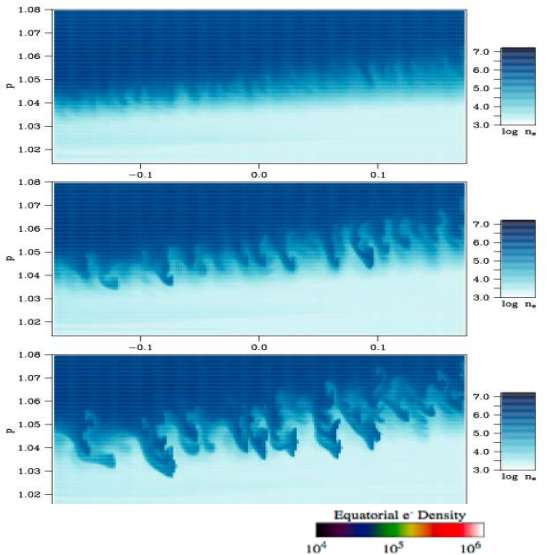
Kil, Hyosub, et al. "Coincident equatorial bubble detection by TIMED/GUVI and ROCSAT-1." Geophysical research letters 31.3 (2004).



Plasma Bubbles

About 1.5 Hours to form a bubble

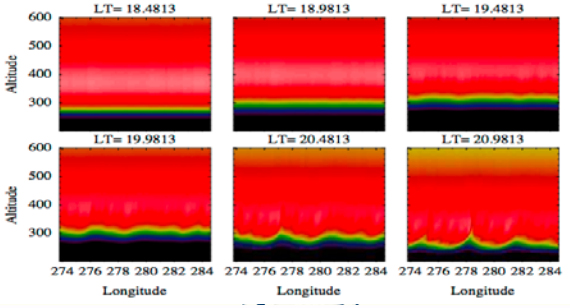




What is the state of the ionosphere here?

That leads to bubbles here ?

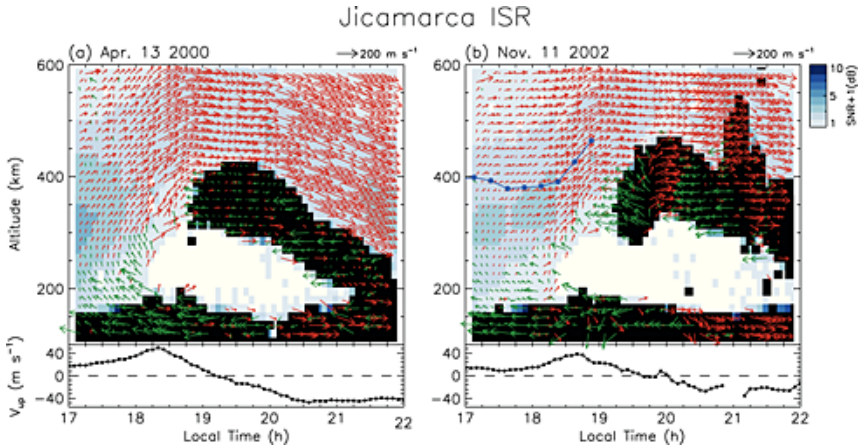
When bottom side seeding perturbations seem to always be present

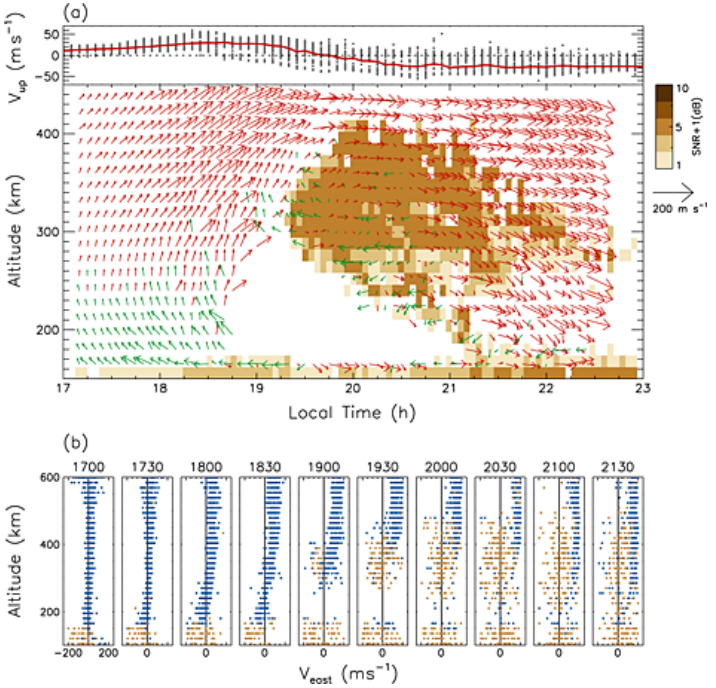


Retterer, J. M., and P. Roddy. "Faith in a seed: on the origins of equatorial plasma bubbles." Annales Geophysicae. Vol. 32. No. 5. Copernicus GmbH, 2014.

Motion of Ionosphere (From Radar)

Morphology of the post-sunset vortex in the equatorial ionospheric plasma drift

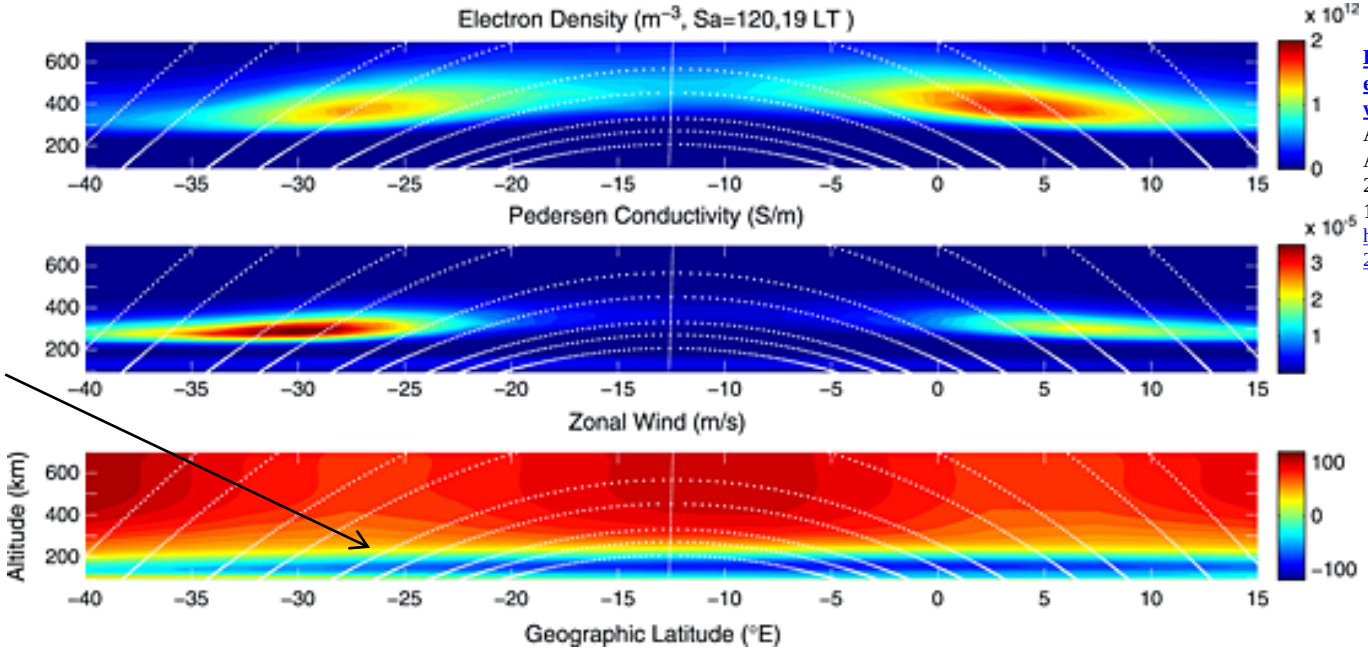




Geophysical Research Letters
Volume 42, Issue 1, pages 9-14, 8 JAN 2015 DOI: 10.1002/2014GL062019
http://onlinelibrary.wiley.com/doi/10.1002/2014GL062019/full#grl52441-fig-0001

Neutral Winds and Conductivities

The importance of winds in different regions to triggering EPB particularly wind shears on the bottom of the ionosphere



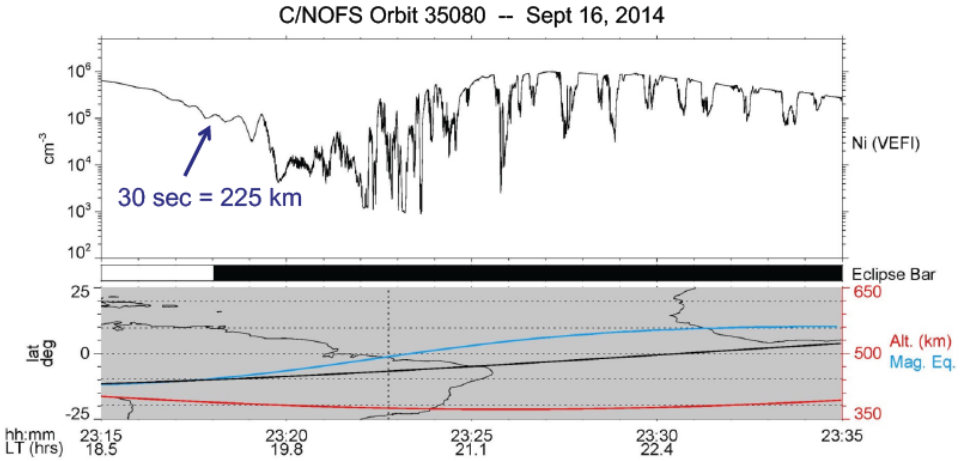
Vertical Wind Shear

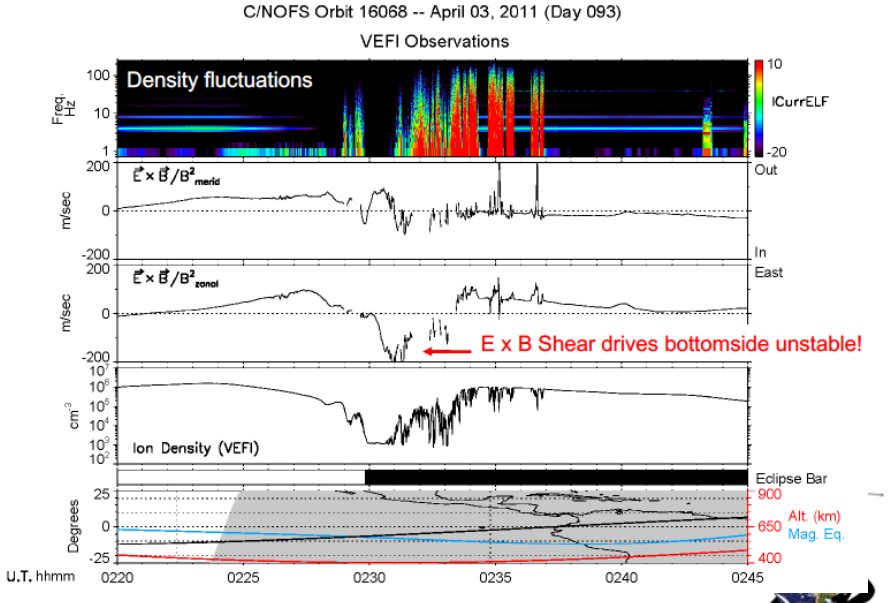
Electrodynamics of the equatorial evening ionosphere: 1. Importance of winds in different regions
Authors A. D. Richmond, T.-W. Fang, A. Maute First Published: 7 March 2015 Vol: 120, Pages: 2118–2132 DOI: 10.1002/2014JA020934
http://onlinelibrary.wiley.com/doi/10.1002/2014JA020934/full#jgra51625-fig-0001

C/NOFS Observations

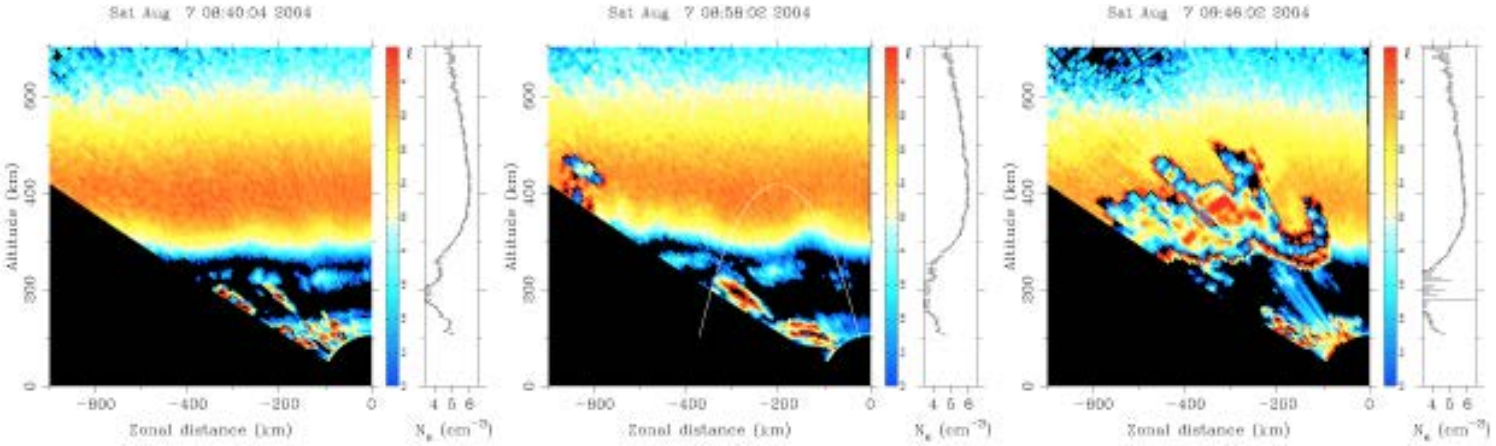
Pfaff, R. F., et al. (2017), Measurement of reversals in the horizontal plasma drifts below the elevated, low latitude F-region at sunset and their implication for the creation of large scale plasma undulations and spread-F irregularities, Journal of Geophysical Research.

Large Scale "Undulations" (100's of km) at Lower Ledge of Ionosphere at Sunset





Bubbles Lead to Scintillations



David Hysell Altair Observations

Not all plasma bubble depletions are associated with scintillations?

Old Bubbles?

New Bubbles?

Science Goals

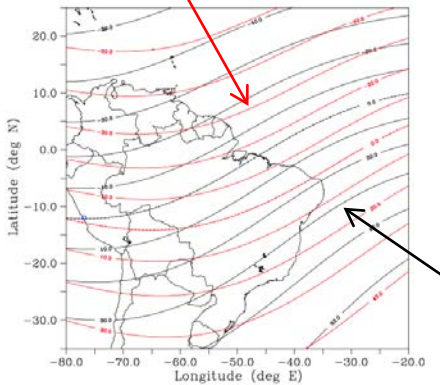
1) What is the state of the ionosphere that gives rise to the growth of plasma bubbles that extend into and above the F-peak at <u>different longitudes</u>?

2) How are plasma irregularities at <u>satellite altitudes</u> related to the radio scintillations observed passing through these regions?

Magnetic Field

Most ground/radar observations come from the American sector of unique magnetic geometry

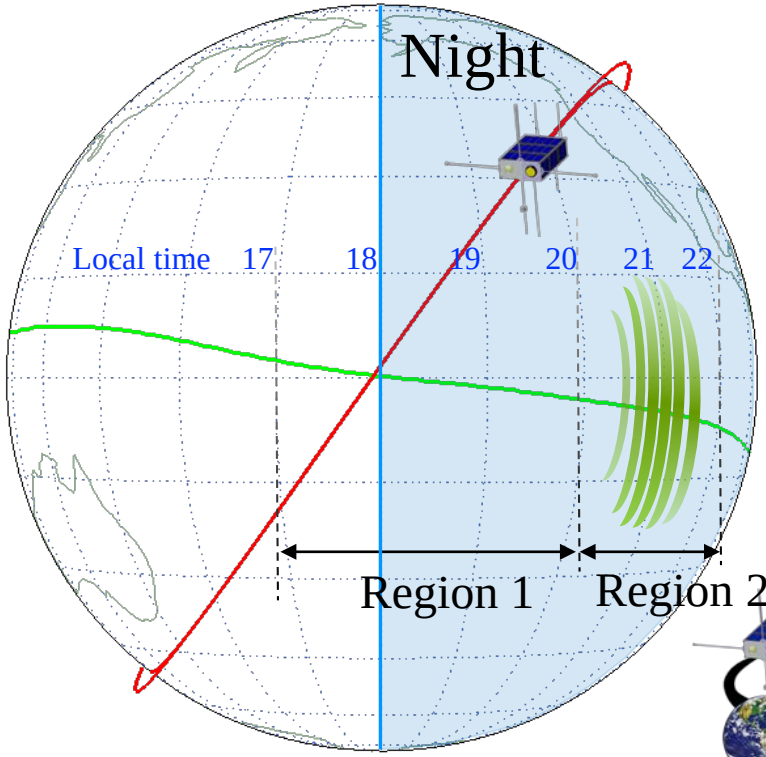
IRGF 1960



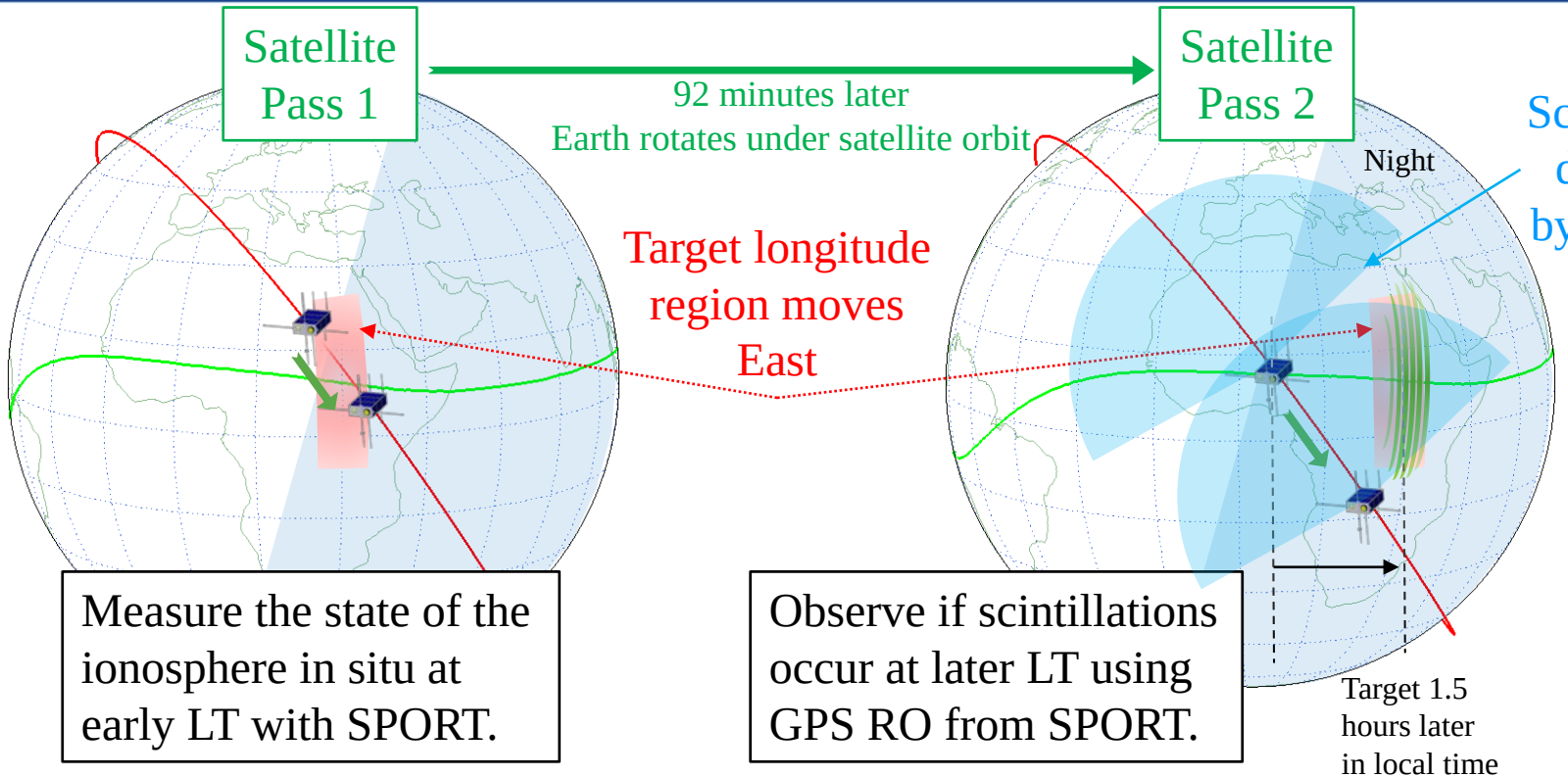
IRGF 2010

SPORT Methodology

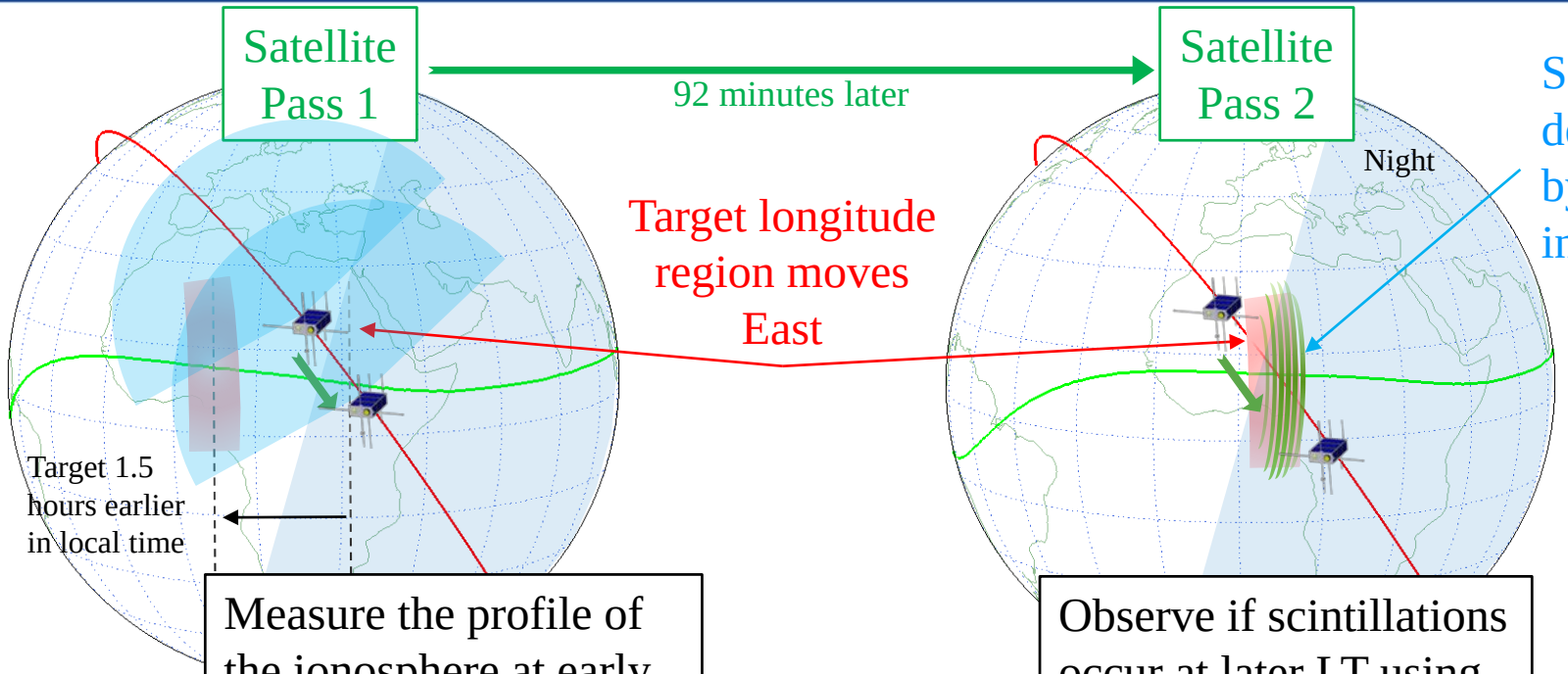
- **The state of the ionosphere at early local times is related to the occurrence of scintillations at later local times.**
  - How does this relation vary with longitude?
- **Use case studies when SPORT ascending or descending node is within 17 to 24 LT sector.**
- **Examine ~15 degree longitude sectors**



Methodology Strategy 1



Methodology Strategy 2



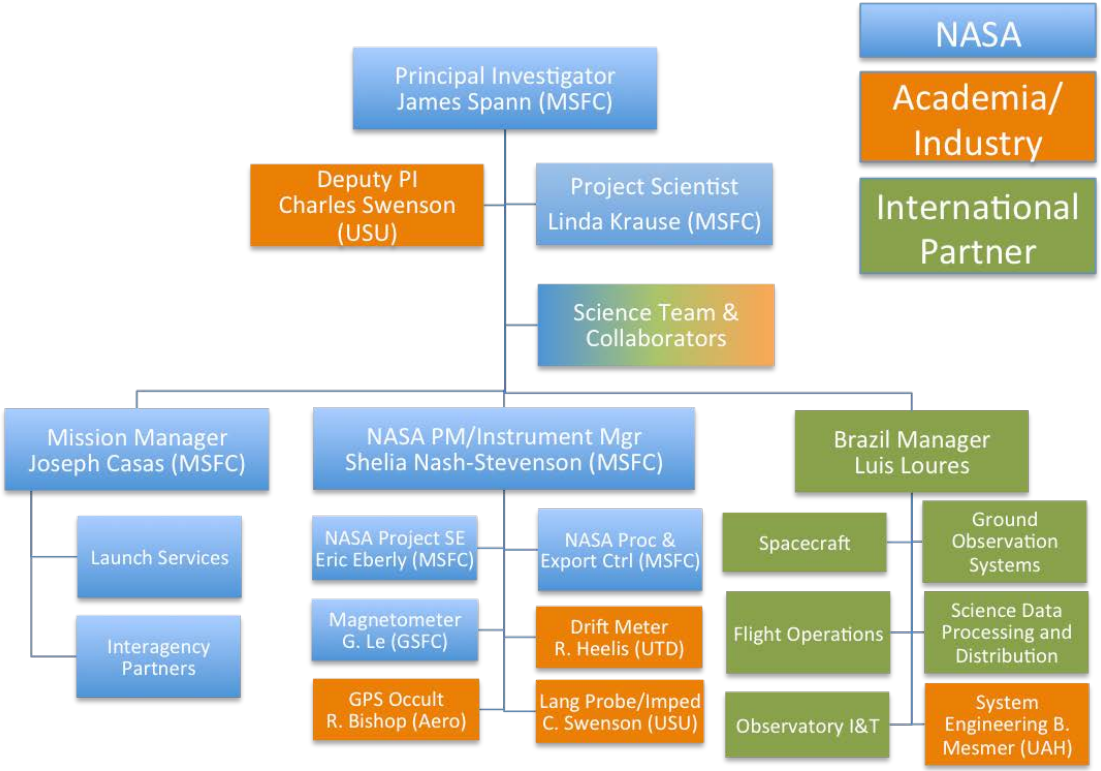
Status

J. Spann, L. Loures

Roles & Responsibilities

J. Spann, S. Nash-Stevenson

Organization



SPORT WBS

- **Shelia to add content**

SPORT Schedule

- **Shelia to add content**

SPORT Milestones

- **Shelia to add content**

Science Plan

L. Krause

SPORT Science Plan Outline

1. Document Purpose and Scope
2. SPORT Mission
3. Background of EPS and Scintillations
4. Science Traceability Matrix
5. SPORT Satellite Instruments
6. Supporting Ground-Based Instruments
7. Operations Plan
8. Data Processing and Handling
9. Distribution of Data
10. Science Analysis
11. Mission Success Criteria and Metrics for Science Closure
12. Publications and Presentations of Findings
13. Opportunities for Collaboration
14. Conclusions and Closing Remarks

Mission Requirements

E. Eberly, O. Durão

Mission Requirememts

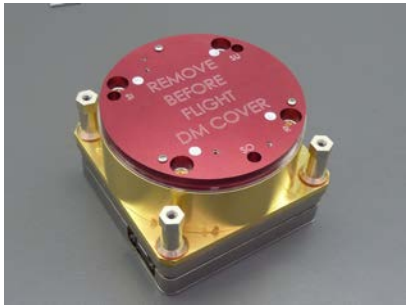
- **Eric to add content**

SPORT Instruments

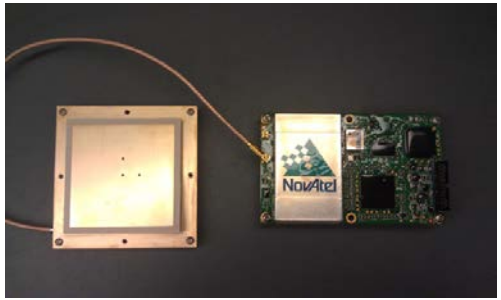
- Magnetometer – G. Le
- GPS Occultation Instrument – R. Bishop
- Langmuir and Impedance Probes – C. Swenson
- Drift Meter – R. Heelis

SPORT Instruments

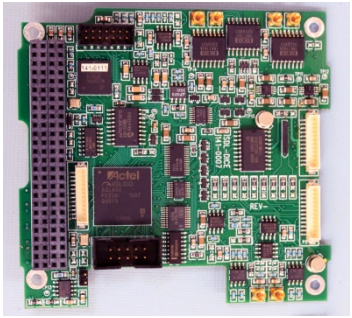
Ion Velocity Meter
UTD



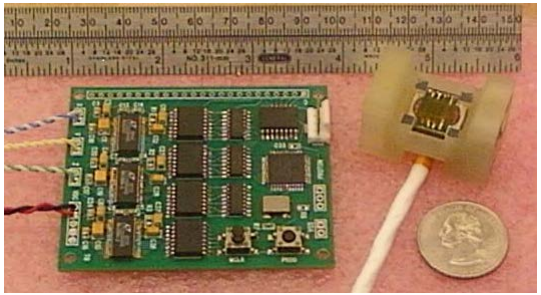
GPS Occultation
Receiver
Aerospace

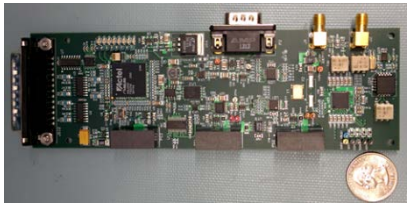


Langmuir, E-field,
Impedance Probe
USU



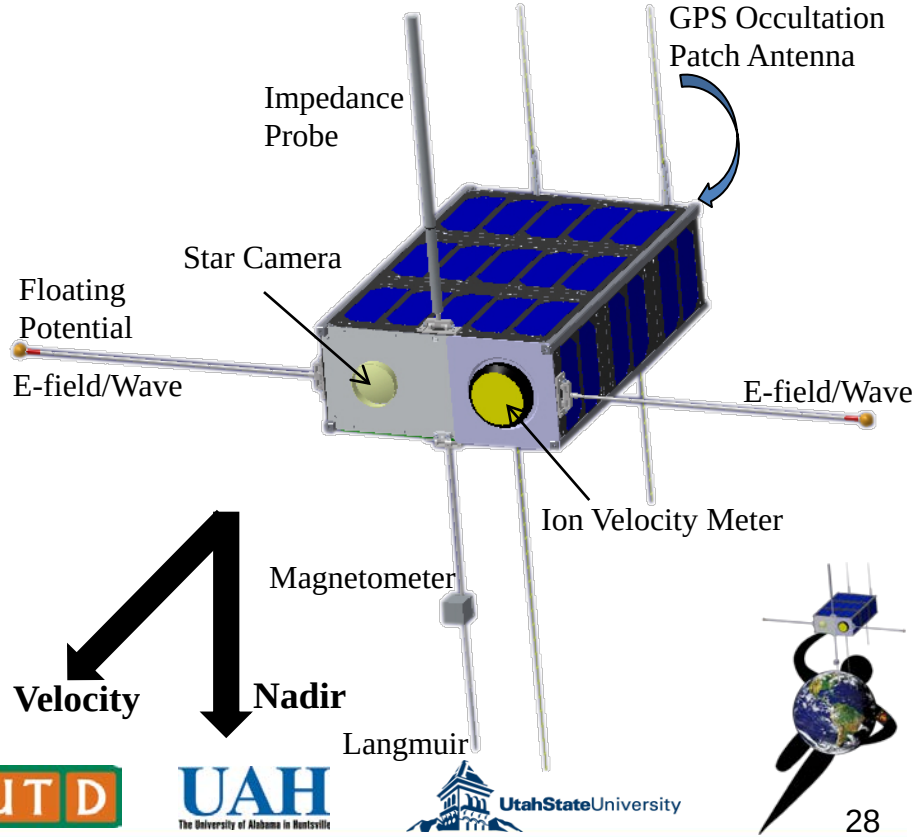
Fluxgate Magnetometer
NASA Goddard





Measurement and Instrumentation

Measurement	Instruments
Plasma motion	RPA/Drift meter
Plasma density / density profiles	GPS Occultation
Small scale structures and waves	Langmuir
Scintillation Index	Impedance
Magnetic field structure	E-Field
Plasma temperature	Magnetometer



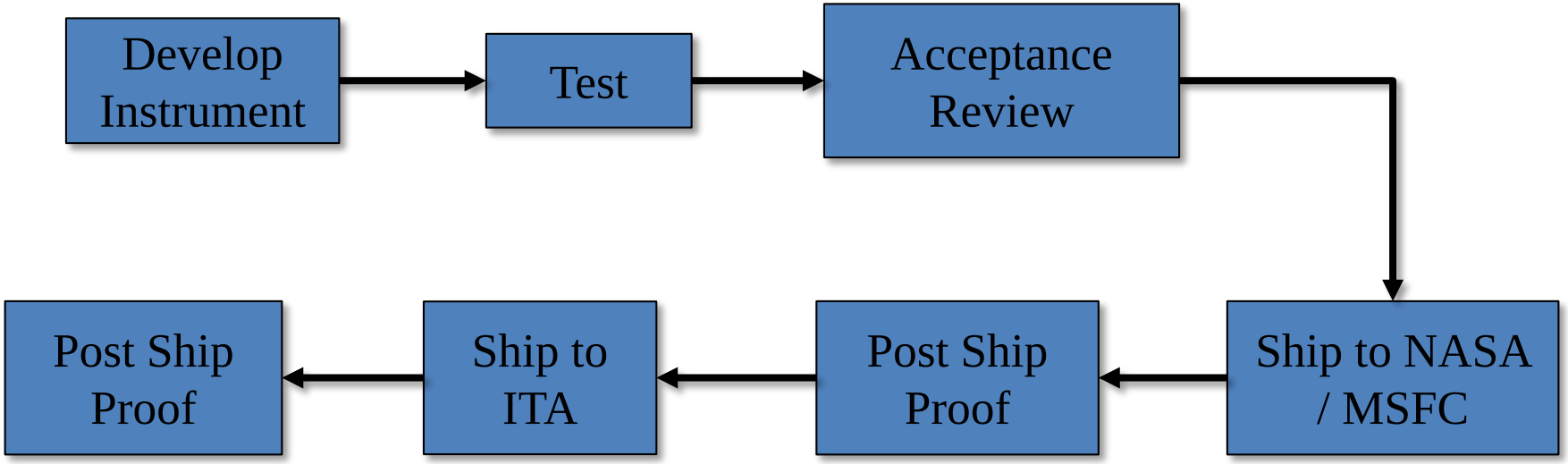
S/C Instrument interfaces

L. Loures

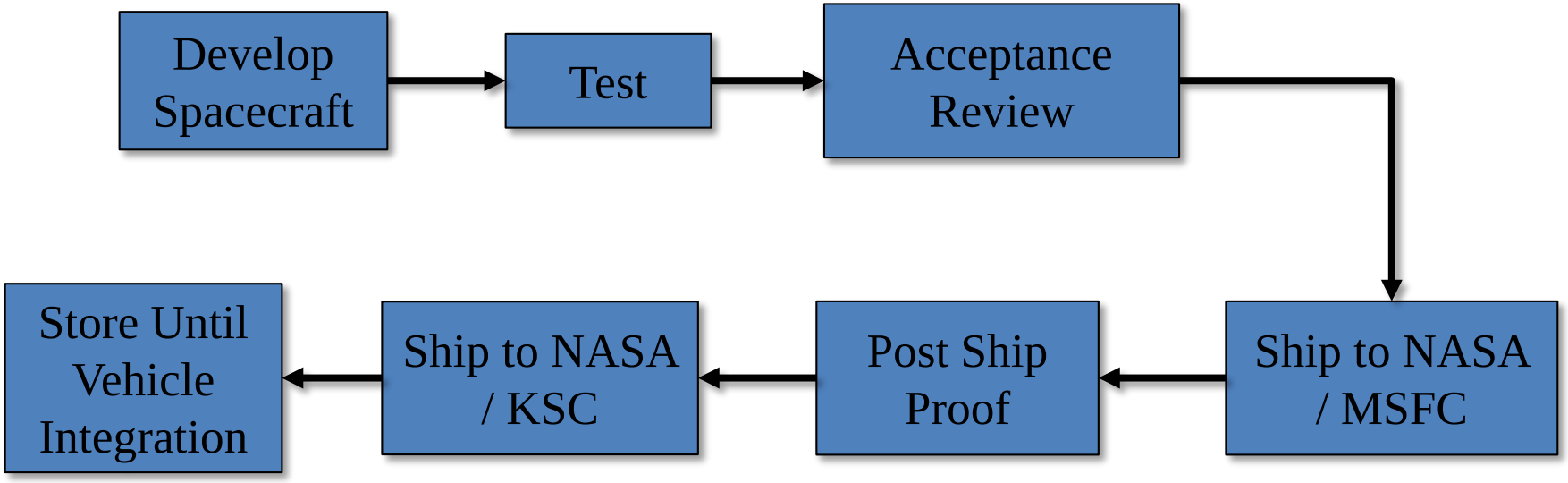
Integration & Test Plan

L Shibuya, J. Sergio, E. Eberly

Typical Instrument Flow



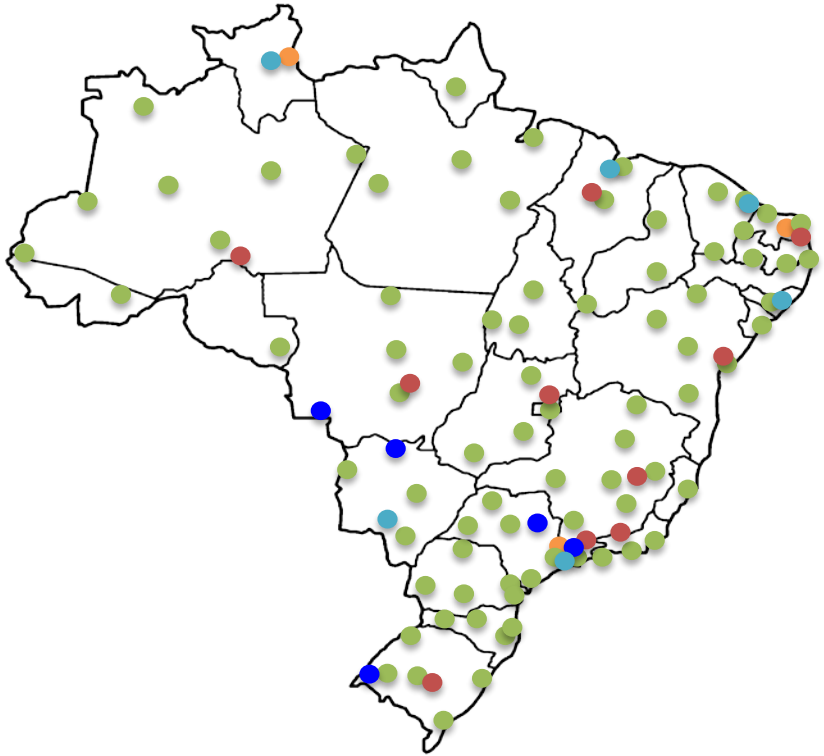
Observatory Flow



Ground Observatory

J. Costa

Ground Network

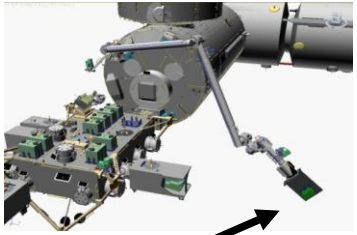


- Magnetometers
- Scintillation sensors
- TEC stations
- Imagers
- Ionosondes

Mission Operations Plan

F. Mattiello

Mission ConOps



SPORT Checkout

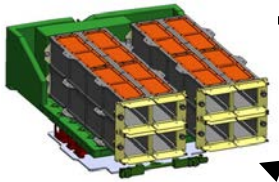
SPORT Operations

On-orbit Operations
(> 12 months)

Deploy from
NANORACKS
400 km alt

Installation

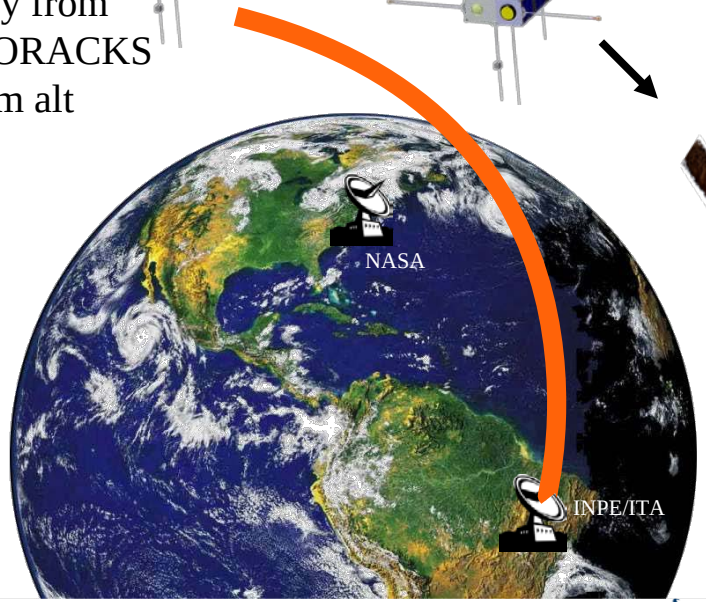
Disposal
300 km alt



Soft
Package

Launch

Images: Charlie Gray



Near-term Issues

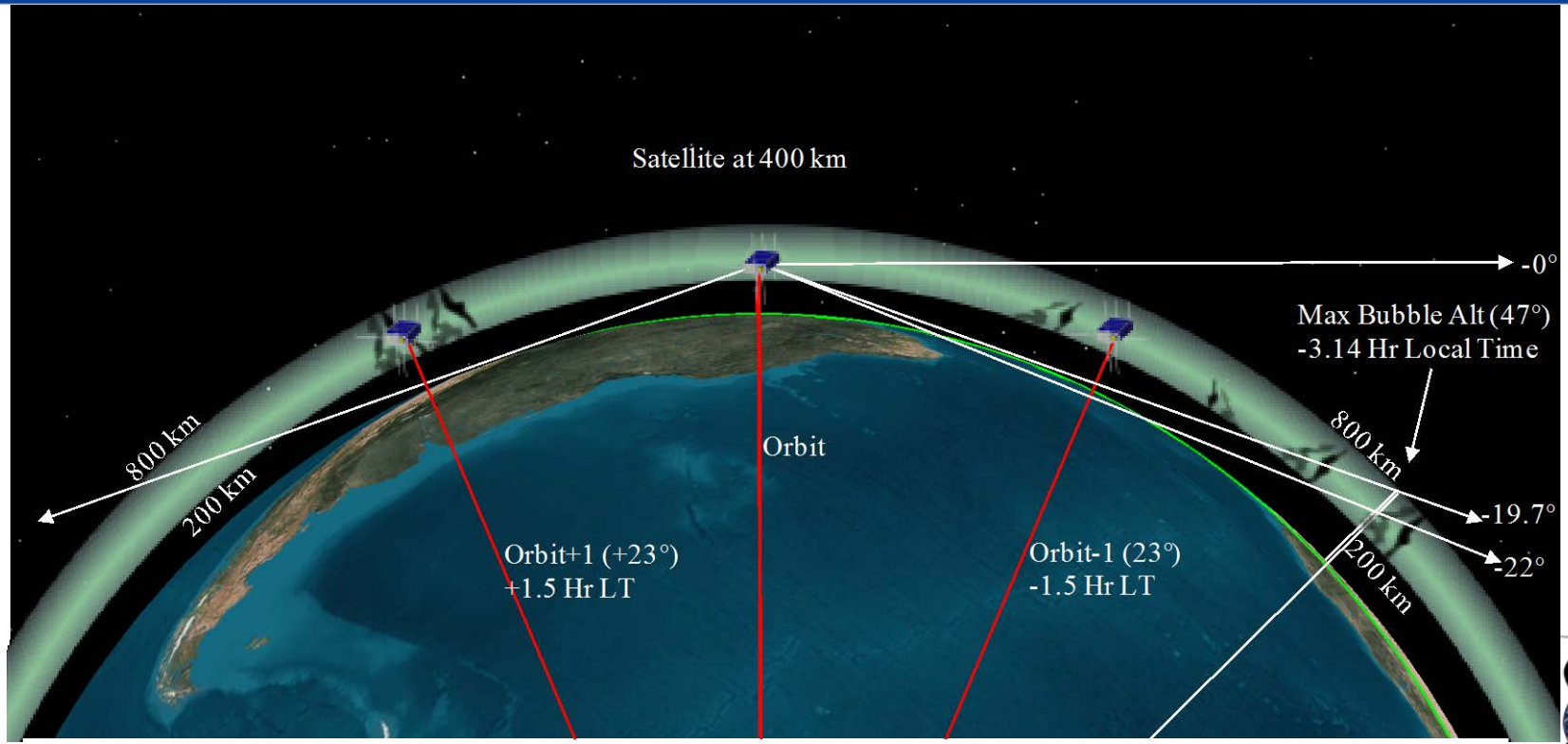
J. Spann, S. Nash-Stevenson, L. Loures

Other Possible CubeSat Missions

O. Durão leads discussion

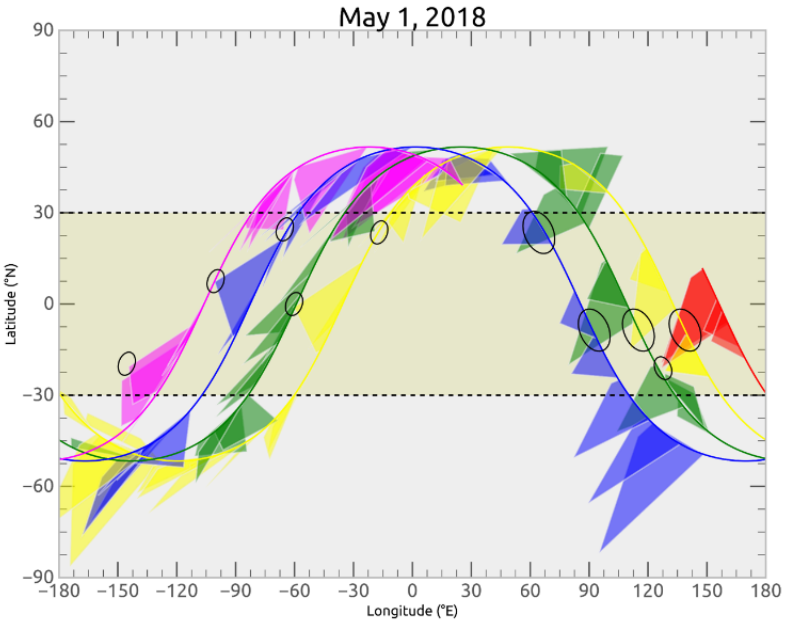
Backup

GPS Radio Occultation and Scintillation



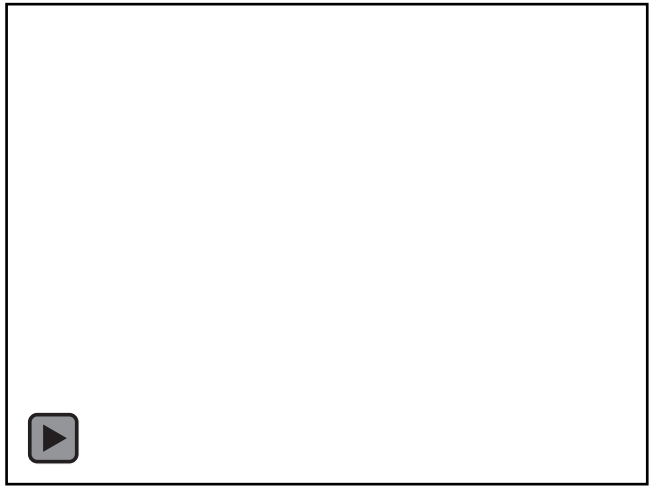
How often are ideal occultation

- **Study using SPORT in ISS orbit.**
- Over one orbit in the region within ±30°
  - ~2 profiles over the previous orbit traces
  - ~2 profiles occur over successive orbit traces.

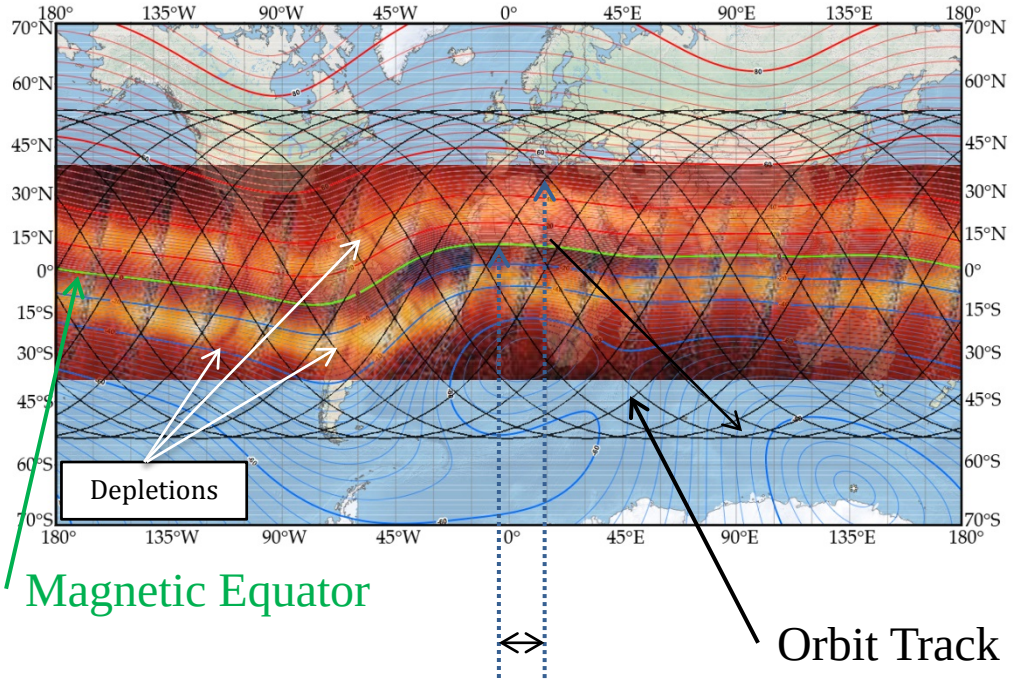


Conclusions

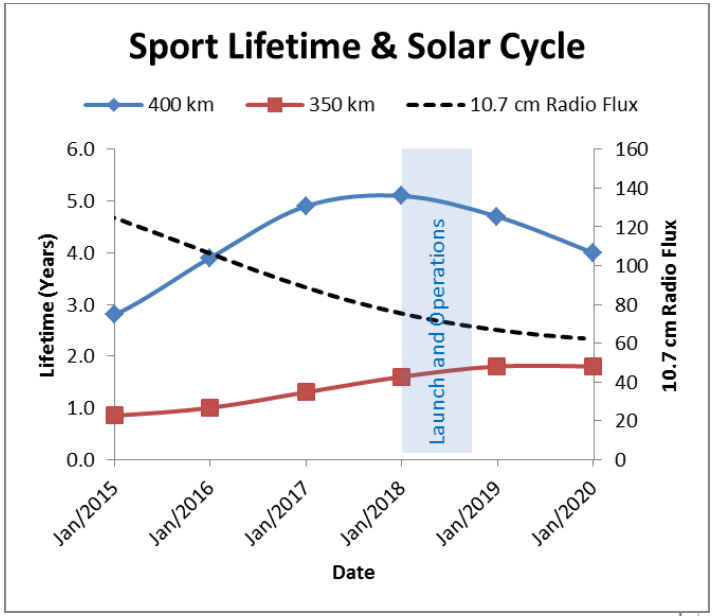
- **CubeSat missions can be developed with a full/regular suite of science instruments.**
- **Mid inclination ISS orbits allow for the deconvolution of local time and longitude at low-latitudes**
- **A String of pearls mission to increase time resolution**



SPORT Mission and ORBIT



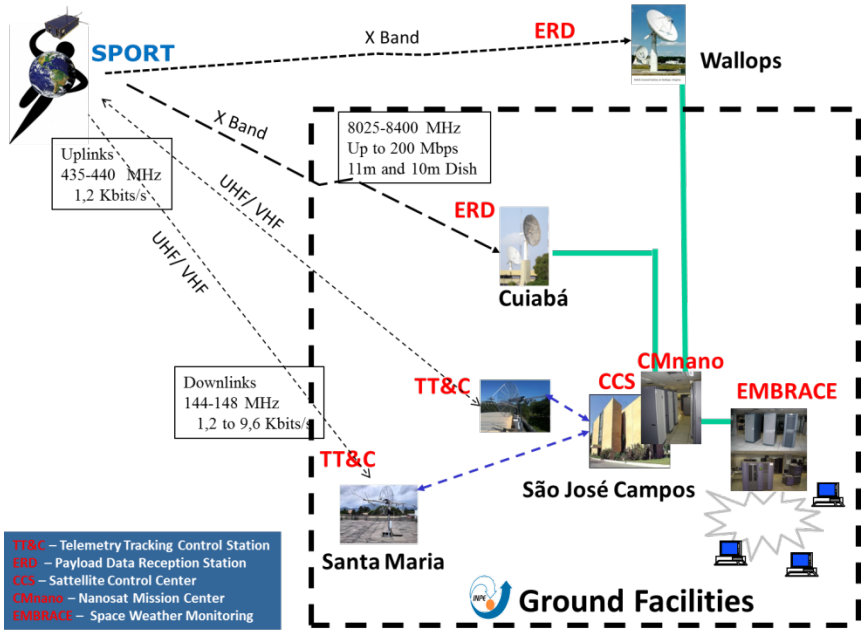
20° latitude or 1.3 hr LT across an EIA arc



Launch from ISS, 400 km Alt
~3 year life

SPORT Telemetry

Channel Name	Duty %	Rate Hz	Bit Rate bps	Alongtrack km
Ion Velocity Meter			**1824**	
Drifts	100%	2.00	288	3.83
Composition Sweeps	100%	2.00	1536	3.83
GPS RO			**16000**	
Dayside Tracking	50%	1.00	1000	7.66
Nightside Tracking	50%	50.00	15000	0.15
Langmuir Probe			**1984**	
DC Probe	100%	40.00	960	0.19
IV Sweeps	100%	0.04	491.52	191.43
Floating Probe Sweeps	100%	0.04	491.52	191.43
N_e Wave Power	100%	0.04	40.96	191.43
E-Field			**1321**	
DC field	100%	40.00	1280	0.19
E-Field Wave Power	100%	0.04	40.96	191.43
Impedance Probe			**197**	
I & Q Sweep	20%	0.04	196	191.43
Tracking	20%	40.00	192	0.19
Fluxgate Magnetometer			**2880**	
DC field	100%	40.00	2880	0.19
Star Imager			**1500**	
Star Subimage	100%	1.00	1500	7.66
Other			**2624**	
Science GPS timeing	100%	40.00	2560	0.19
Science Housekeeping	100%	0.10	64	76.57
Rate collected on orbit			**31210**	



50 Mbit/second Downlink giving a safety factor of 14