A “ThinSat” to Characterize Deorbitization due to Ionospheric Drag and Local Plasma Dynamics

UNITED STATES NAVAL ACADEMY
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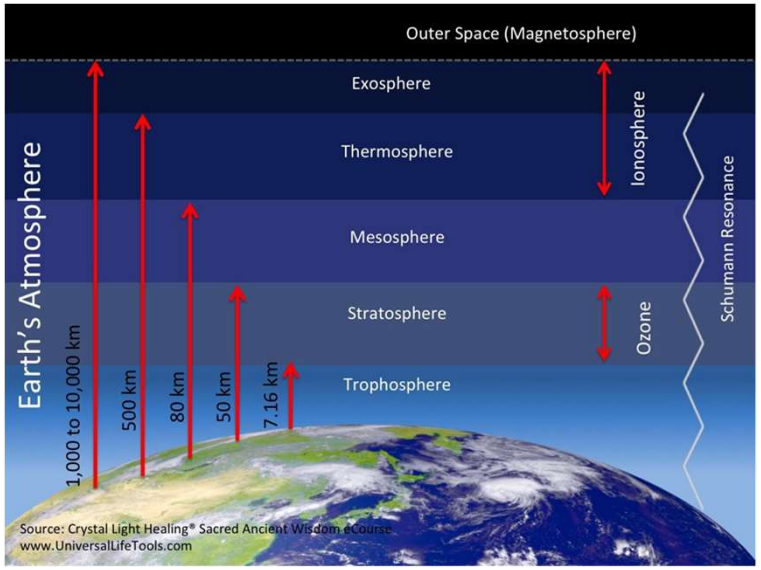
Agenda

- Ionosphere Description and Significance
- Challenges in Studying Lower Atmosphere
- Solutions to Challenges – using ThinSats
- Mission and Mission Objectives
- Expected Outcomes
- Contributions and Conclusions

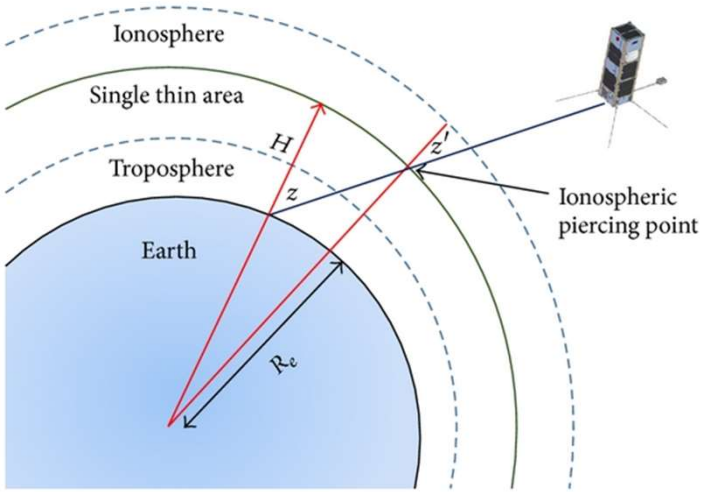
Importance of The Ionosphere

- Layer of the atmosphere between 60-1000 km including positively charged particles
- Necessary for long range radio wave propagation.



Why it Matters

- Our current knowledge is limited
- Better the model for deorbitization
- Future technologies: communications and other applications, including military & civilian

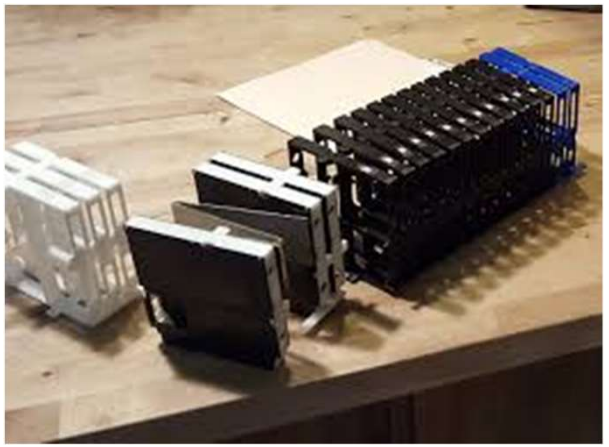


Solutions to Gathering Data

- Low altitude data collection
- Low cost missions
- Effective, small payloads – ThinSat

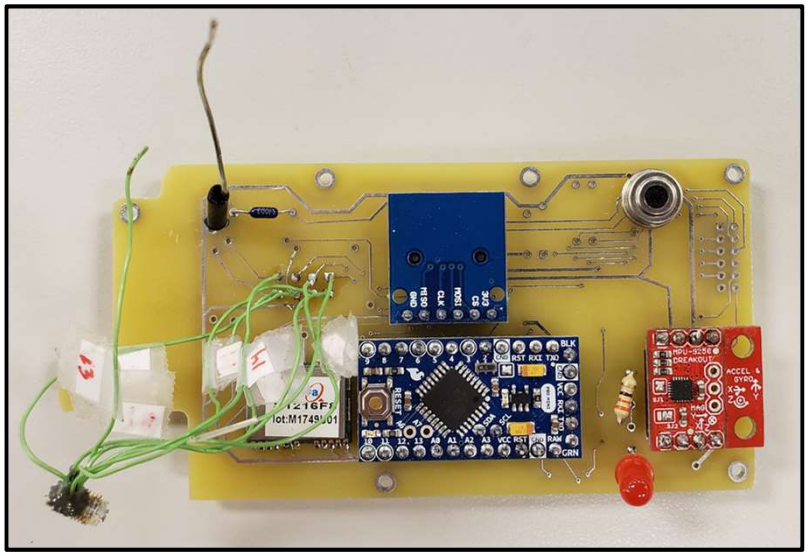
What is ThinSat?

- Cheaper means to collect data from space and demonstrate technologies
- 1/7 the size of a traditional CubeSat



Introduction To Our ThinSat

- Data collection card is housed in ThinSat spacecraft
- Collect large amounts of data from a small form factor



Mission Statement

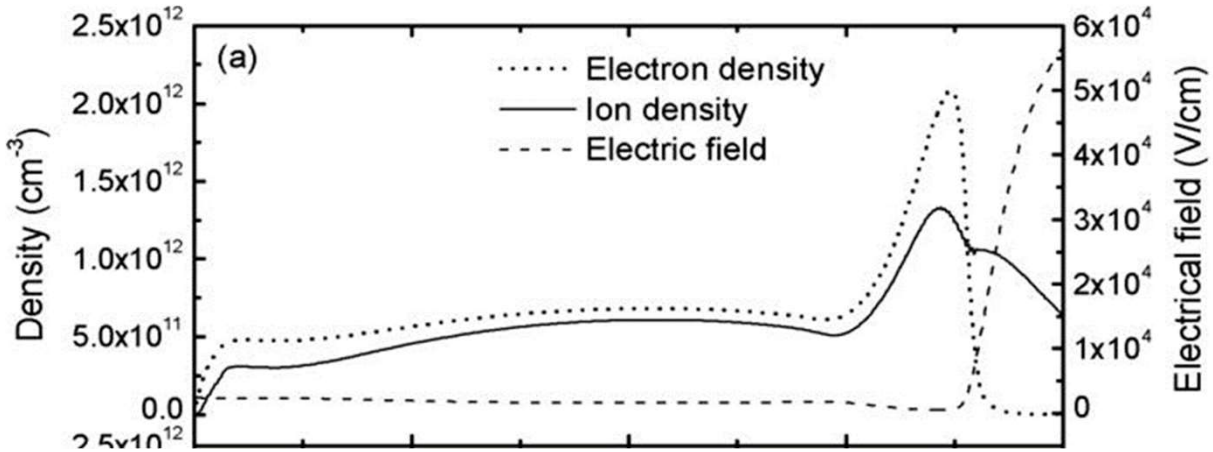
Mission: To measure and relate the orbital degradation due to the ionosphere. To examine the effects of deorbitization through the ionosphere in order to determine the changes in the plasma density gradient between daylight and eclipse

Objectives:

- Determine the effects the ionosphere has on deorbization
- Prove that small satellites are capable of gaining scientific insight and educational experience

Determination of Ionosphere Density

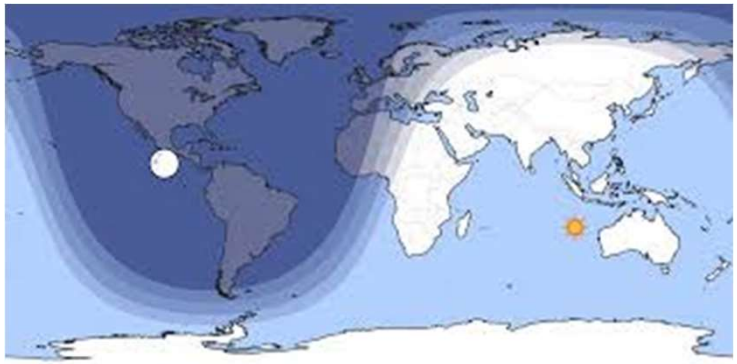
- Ionosphere size and density varies with temperature
- Resulting in higher drag



Determine Daylight And Eclipse

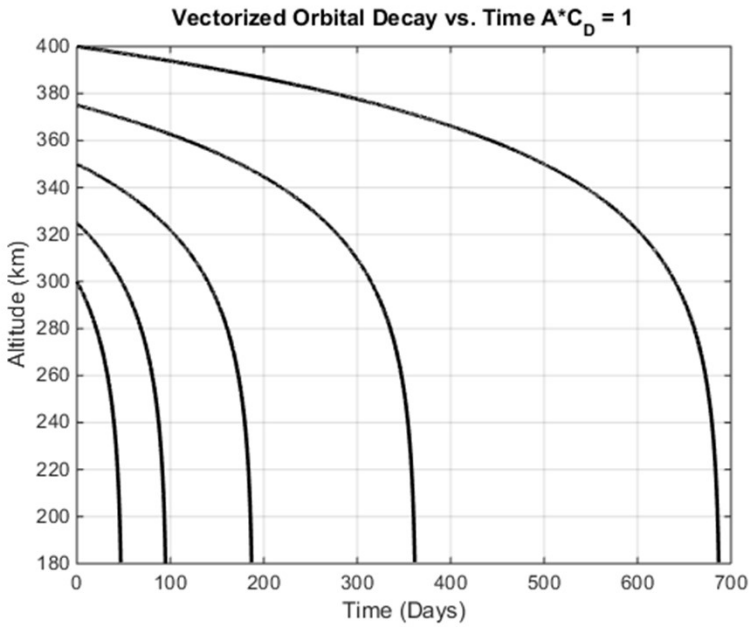
- Temperature gradient is affected differently by the ionosphere during exposure to sun versus eclipse
- Temperature will observe an overall increase as satelite deorbits.

- ~60 minute daylight
- ~30 minute eclipse



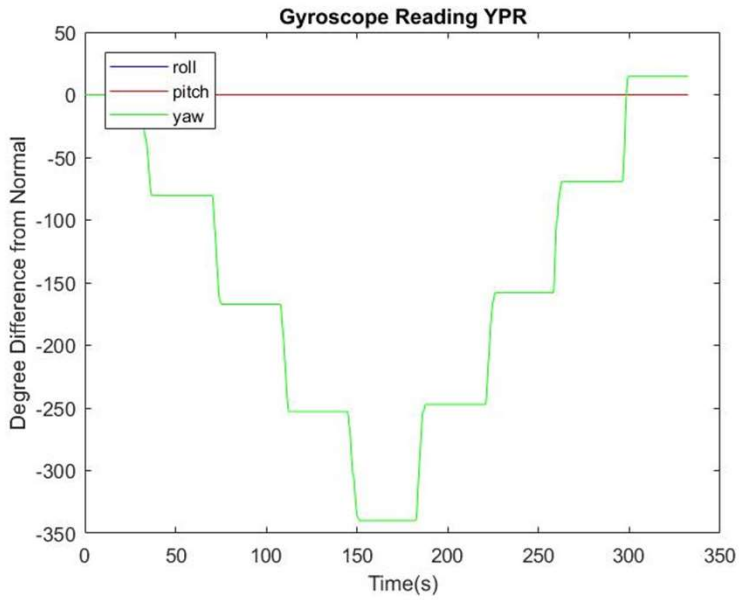
Objective: Orbital Degradation

- How does the ionosphere affect how a satellite falls from orbit?
- Minimal data has been collected on this specific topic
- Allows for data correlation



The Data to be Collected

- Global Positioning System (GPS):
  Positional data
- Inertial Measurement Unit (IMU):
  Satellite dynamics
- Thermometer:
  Temperature Data
- Electrometer:
  Plasma Density



Positional Data

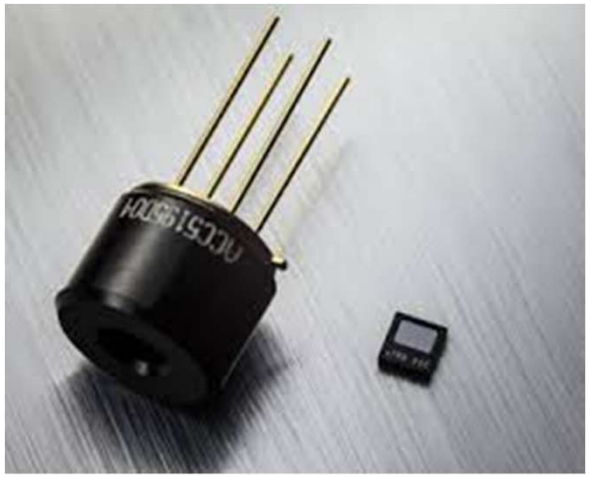
- Skytraq S1216F9 GPS
  - An inexpensive, GPS module that has never flown in space before as a test for future missions
  - If the GPS proves ineffective, mission is not compromised

Satellite Dynamics

- MPU-9250 IMU
  - 9-axis MEMS sensor
  - Includes Gyro, Accelerometer, Magnetometer
  - Help to determine changing orbital characteristics during deorbitization

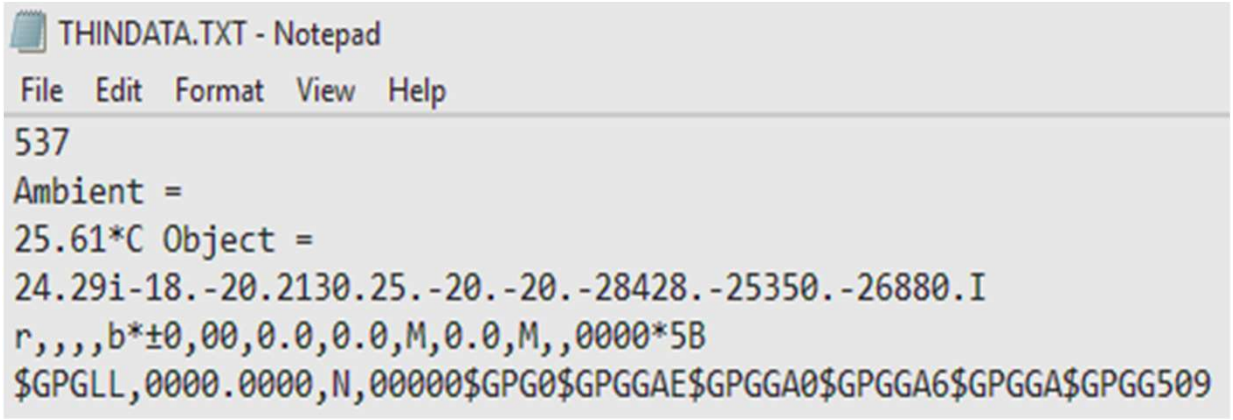
Temperature Collection

- Melexis Infrared Thermometer
  - Tolerances high enough to handle broad temperature range
  - Expected temperature range: 200-500 K



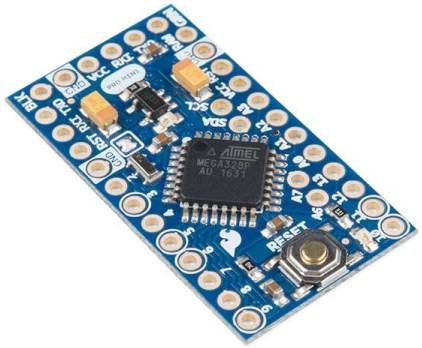
Electrometer Sensor Payload

- Measures surrounding electric field
- Output detects changes in electric field
- Electron density obtained from measured changes
- Data results in quantifying of dynamic plasma environment



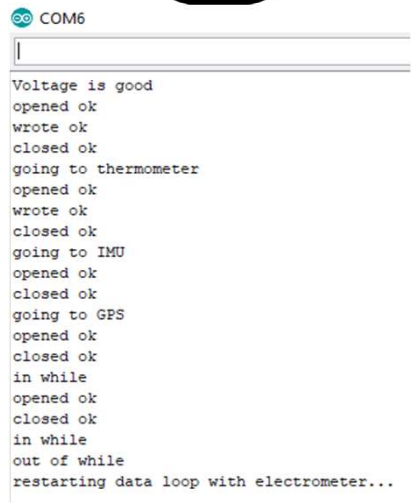
Command and Control Unit

- Arduino Pro Mini
  - Execute scripts from sensor data collection
  - Compresses data
  - Stores the data before download



Concept of Operations Overview

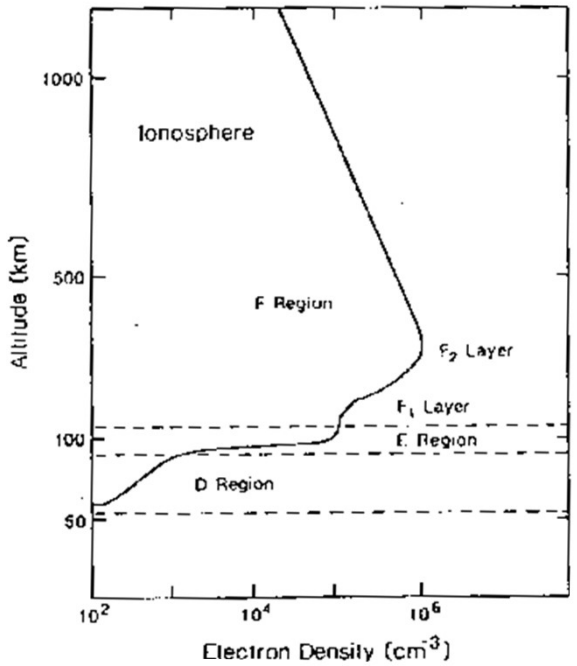
- Standby Mode
  - Activated and powered through trickle current
  - Able to detect when power received is above threshold
- Data Collection Mode
  - Triggered by receiving threshold power
  - Steps through each instrument and records singular data point
  - Data is written to a text file on a micro SD card
- Data Transmission Mode
  - File on SD card is opened and data is sent to corresponding JP6 pin for transmission
  - SD card is wiped for next data cycle



Data Collection and Transmission Modes are repeated until power can no longer detected. Once this occurs, Standby Mode is activated

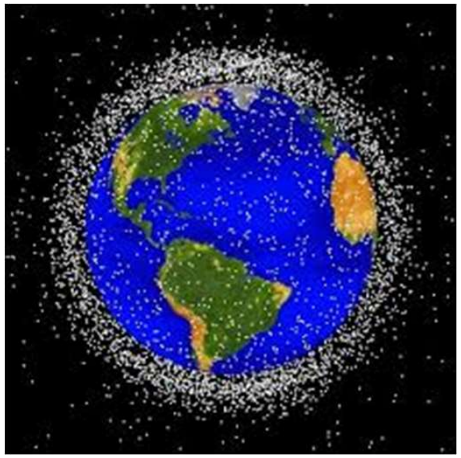
Outcomes

- Measurements of the ionosphere
- Detection of ionosphere abnormalities
- Examination the differences between the day and eclipse cycle for orbital decay
- Identify a correlation between deorbitization and plasma density



Contribution to Community

- Better understanding of the effects of ionospheric drag caused by changing plasma densities on the deorbization of satellites.
- Test of new, unflown hardware
- Practical educational experience for space explorers



Conclusion

- Identify the changes of the plasma density of the ionosphere and its correlation with de-orbitization
- Measure changes in ionosphere from daylight to eclipse
- To demonstrate that an inexpensive, small satellite can provide valuable insight in the scientific community
- Provide an invaluable educational opportunity to Midshipmen

Questions