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Advancing Ground Station Capabilities: A Web-based Application with GNU Radio for Seamless Satellite Tracking and Communication

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OUTLINE

1. Introduction
2. System Architecture and Design
3. Development
4. Conclusions and Future Work

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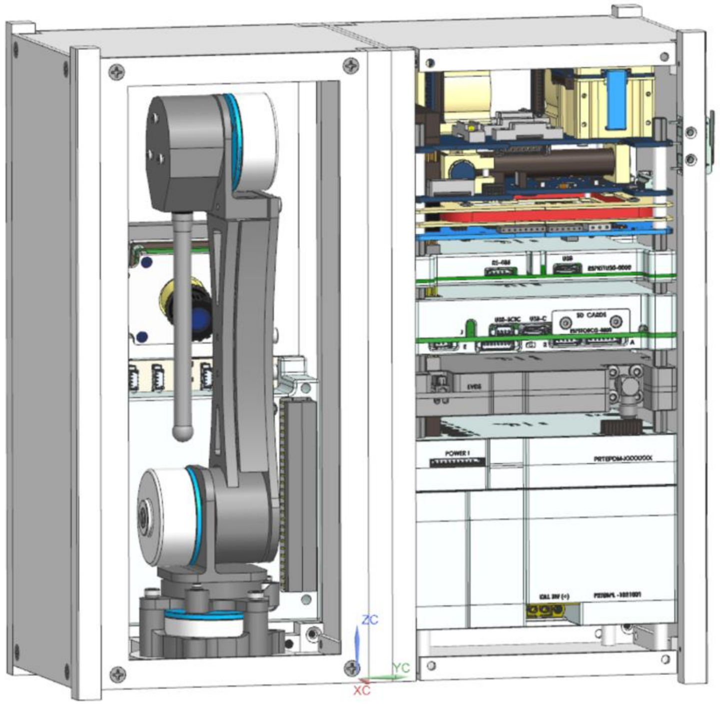
Introduction



CubeSats

- Nano satellites
- Size: 10 cm edge
- Weight: < 1.33 kg
- Benefits: low cost, low complexity, short development time, accessibility, versatility

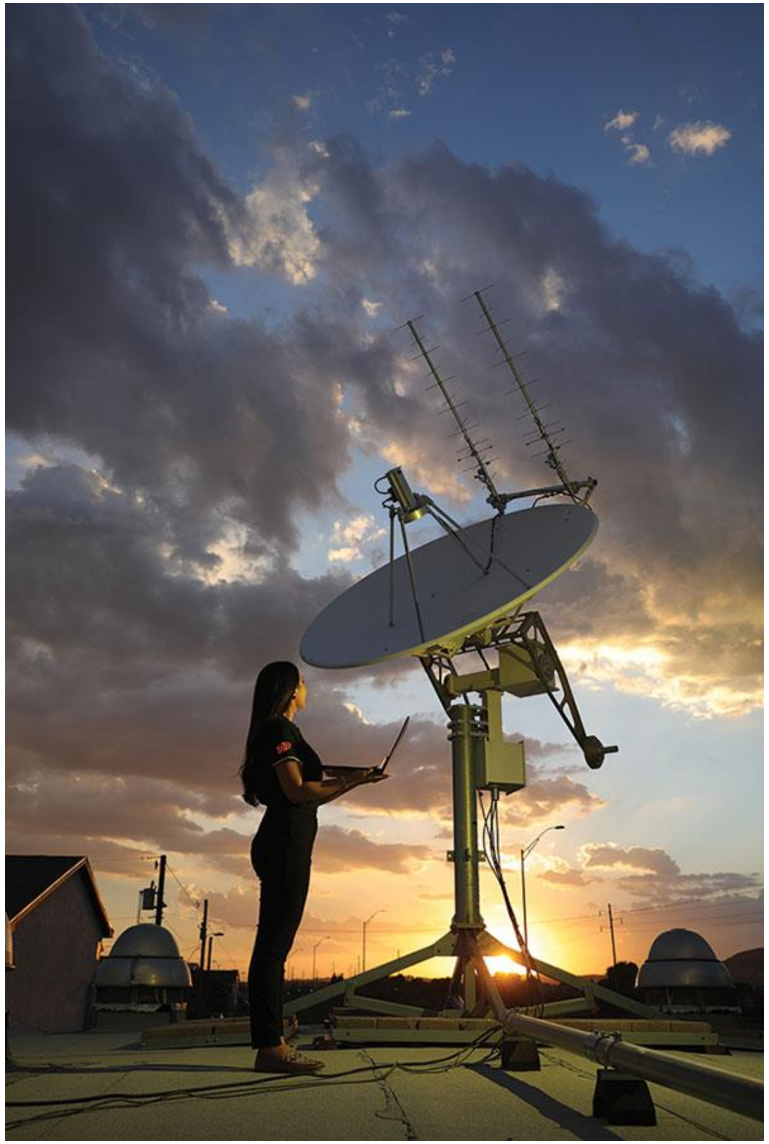
SleeperSat-1

- CubeSat mission by the University of Texas at El Paso’s Aerospace Center
- Scheduled Launch: Mid 2024
- Focus: Rapid-deployment modular CubeSat concept
- Emphasis on digital engineering principles for innovative satellite development

Introduction

SleeperSat-1 Ground Station

- In-house satellite ground station
- Purpose: To automatically track and communicate with satellites operating in UHF and S-Band frequency ranges within a single web-application
- Significance: Streamlines satellite monitoring and facilitates seamless communication, marking a significant advancement in mission control and operations.



Importance of Ground Stations in CubeSat Missions

- Challenges in CubeSat communication:
  - Limited physical space
  - Power scarcity forces strict management for all tasks
  - Complex task of attitude control for power generation and communication
- Ground station support is essential for overcoming these obstacles.
- They enable real-time tracking, data transmission, and command relay.
- Ground station reliability is crucial for mission success.
- Unreliable communication can lead to mission failure and data loss.

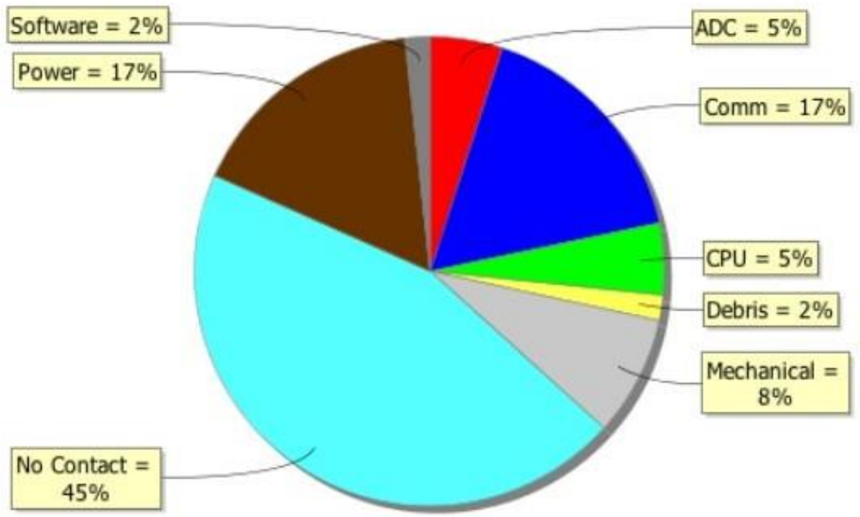


Figure 9. Causes for CubeSat Mission Failure, 2000-2012

System Architecture and Design

Objectives

- Enable live satellite tracking
- Manage real-time communication
- Implement seamless UHF and S-Band signal decoding
- Provide real-time satellite data display
- Promote academic learning through hands-on experience

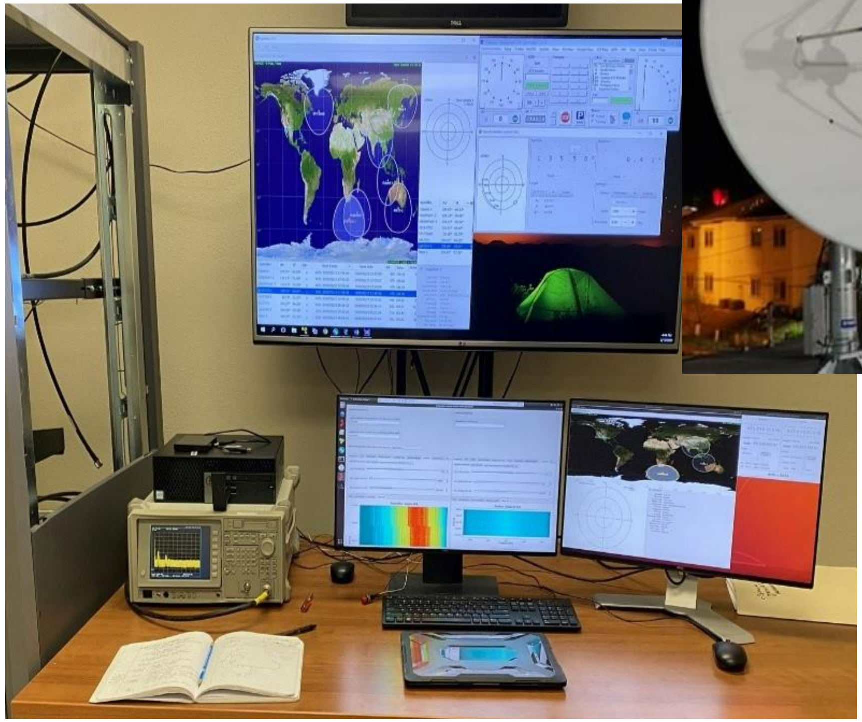
System Components

Hardware

- UHF Cross Polarized Yagi-Uda Antennas
- S-Band Parabolic Reflector Antenna
- Azimuth and Elevation Rotor Controller
- USRP x300 Software-Defined Radio

Software

- Ground Station computer (Linux OS)
- GNU Radio
- Gpredict
- Server



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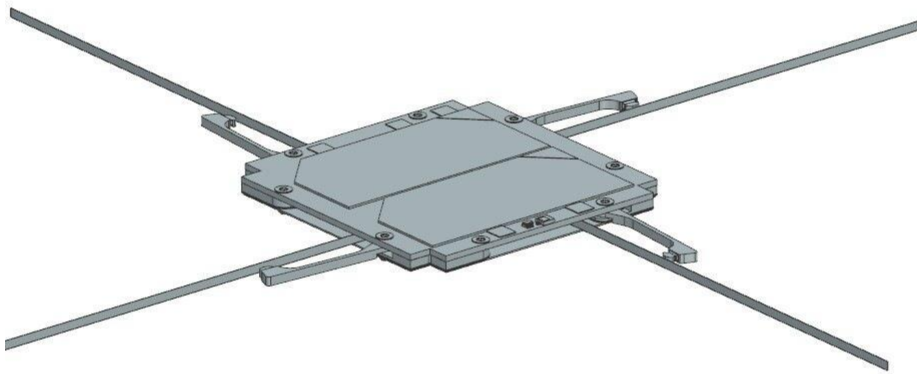
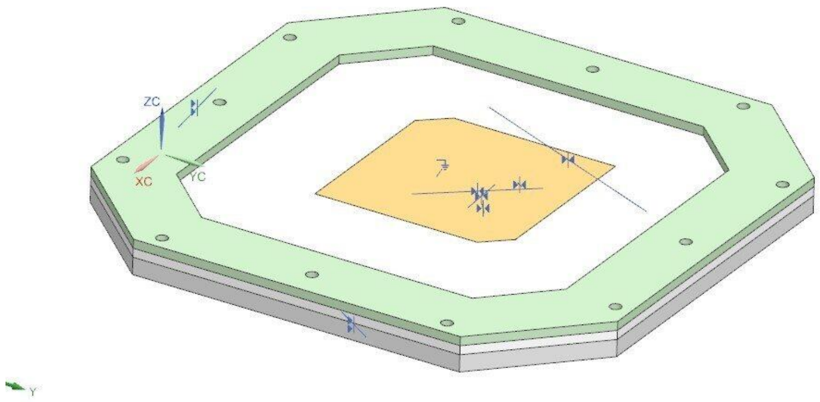
Communication Configuration





SleeperSat-1

- UHF Transceiver (Half-Duplex)
- Deployable UHF Antenna
- S-Band Transceiver (Full-Duplex)
- Patch S-Band Antenna
- Modulation Scheme: Quadrature Phase Shift Keying (QPSK)
- Communication Protocols:
  - AX.25 Packet Protocol
  - ESTTC Protocol (EnduroSat Standard Telemetry and Telecommand Communication)

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System Development

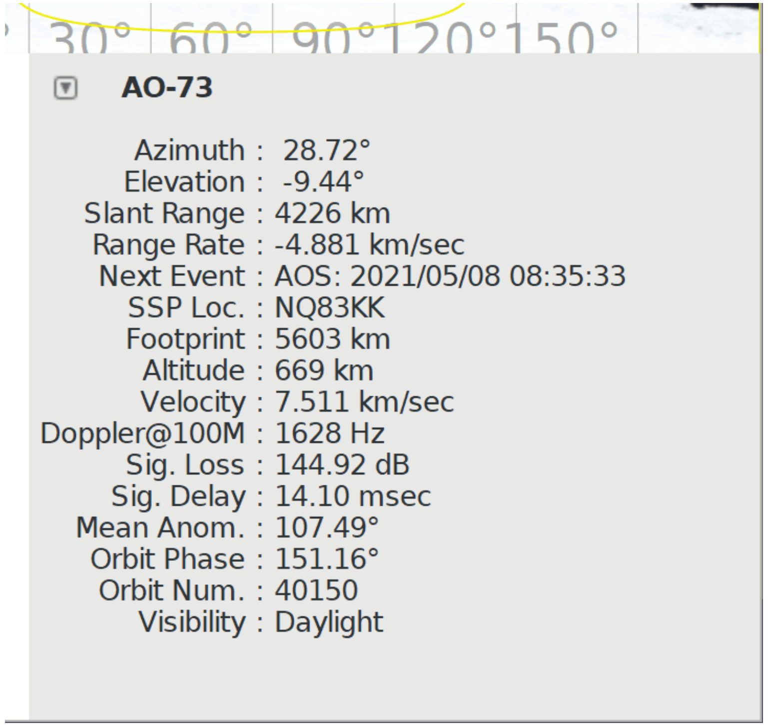
Satellite Tracking Capabilities

GPredict Integration:

- TLE Data Updates
- SGP4 Model
- Real-time Positioning

Key Outputs:

- Latitude/Longitude
- Azimuth/Elevation
- Velocity
- AOS/LOS Predictions
- Doppler Shift Correction



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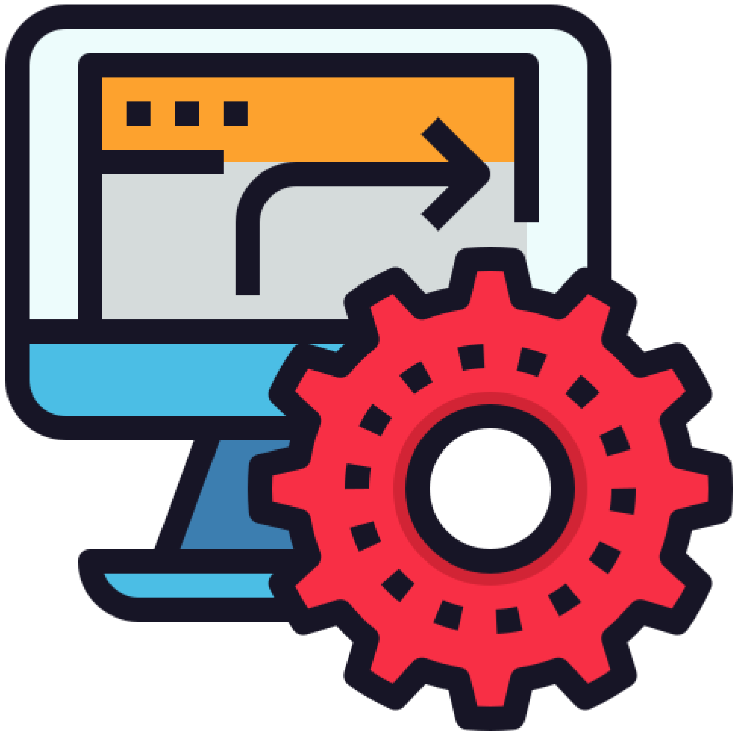
System Development

Communication Scheduling

- Precise Antenna alignment using outputs from backend
- Streamlined Automation: Serial link between ground station computer and rotor controller.
- Anticipating AOS: Transmitting azimuth and elevation values just before Acquisition of Signal (AOS).
- Proactive Tracking: Antennas begin adjusting before satellite enters the communication range.
- Reliable Connectivity: Minimizing signal loss for consistent data collection and transmission.



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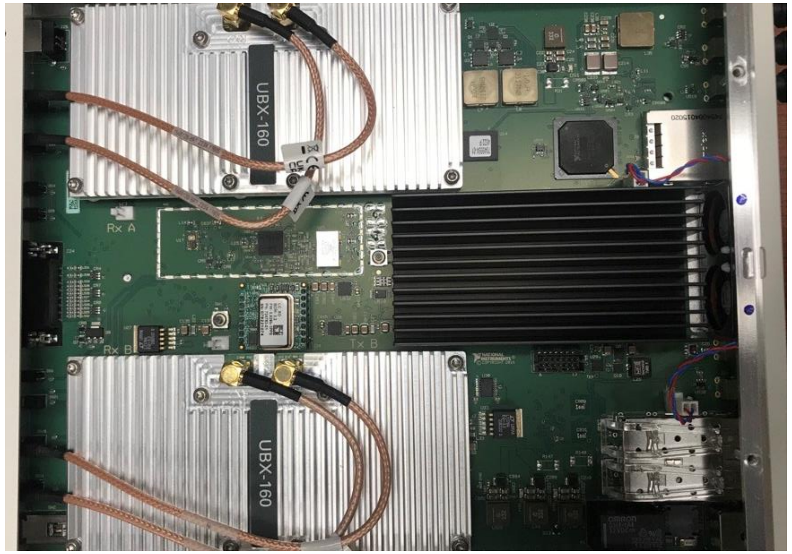
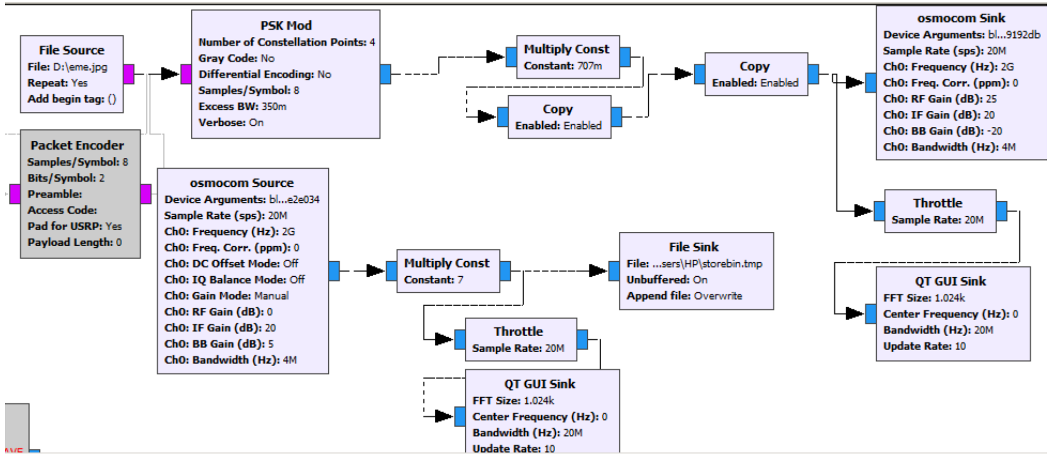




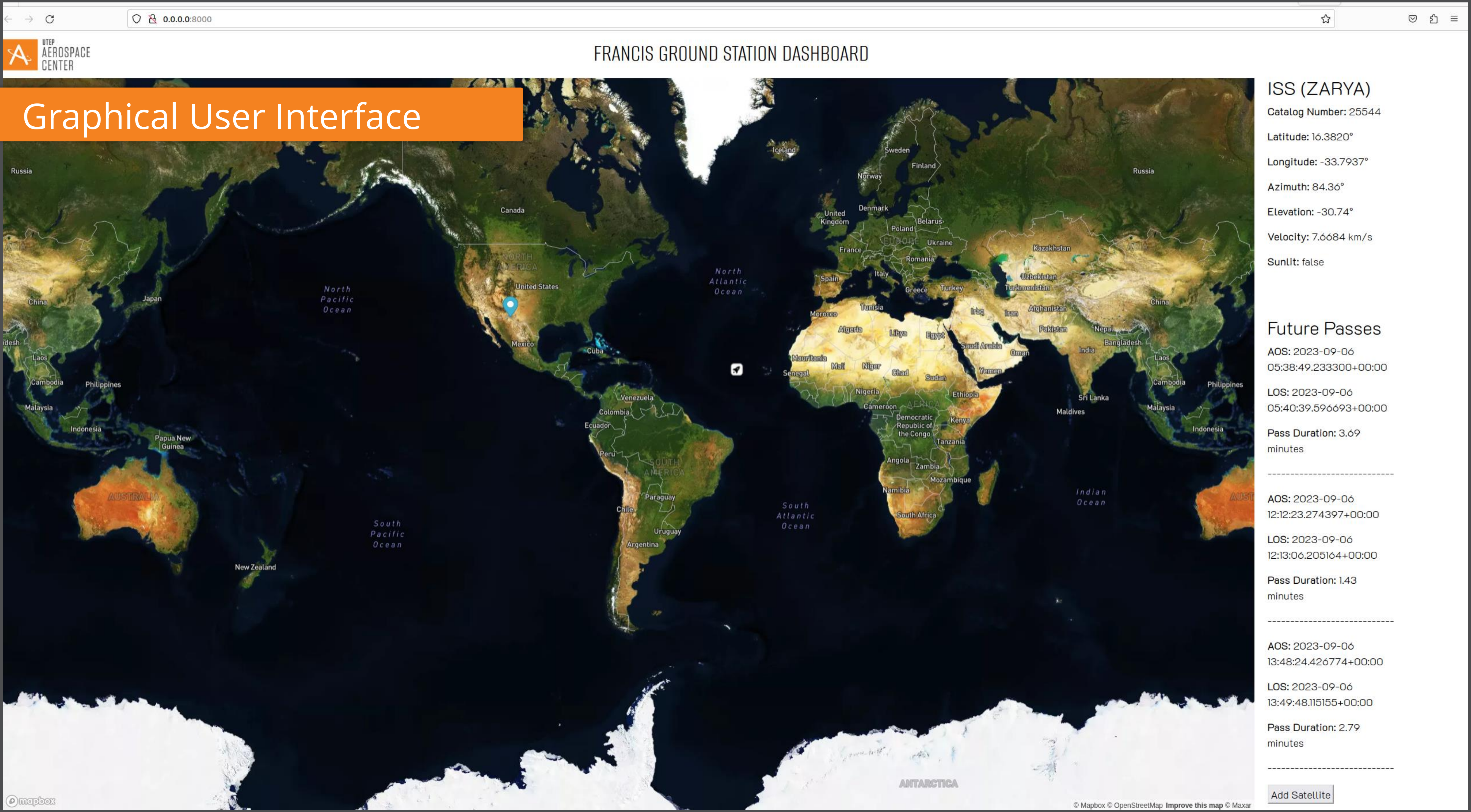
Signal Reception and Processing

USRP x300 with Dual Daughterboards: Adaptable hardware supporting diverse CubeSat frequencies and signal types.

Seamless Integration with GNU Radio: Leveraging GNU Radio's Python API for signal processing within our web application.

1. **Signal Decoding:** Custom scripts decode incoming data from USRP x300, extracting mission-critical information.
2. **Enhanced Data Integrity:** Robust error correction codes guarantee data accuracy, even in challenging signal conditions.
3. **Structured Data:** Parsed data conforms to predefined protocols, ensuring accessibility for mission control and analysis.
4. **Real-time Data Display:** Processed data displayed in real-time on our web app, enabling continuous satellite status monitoring.

Graphical User Interface



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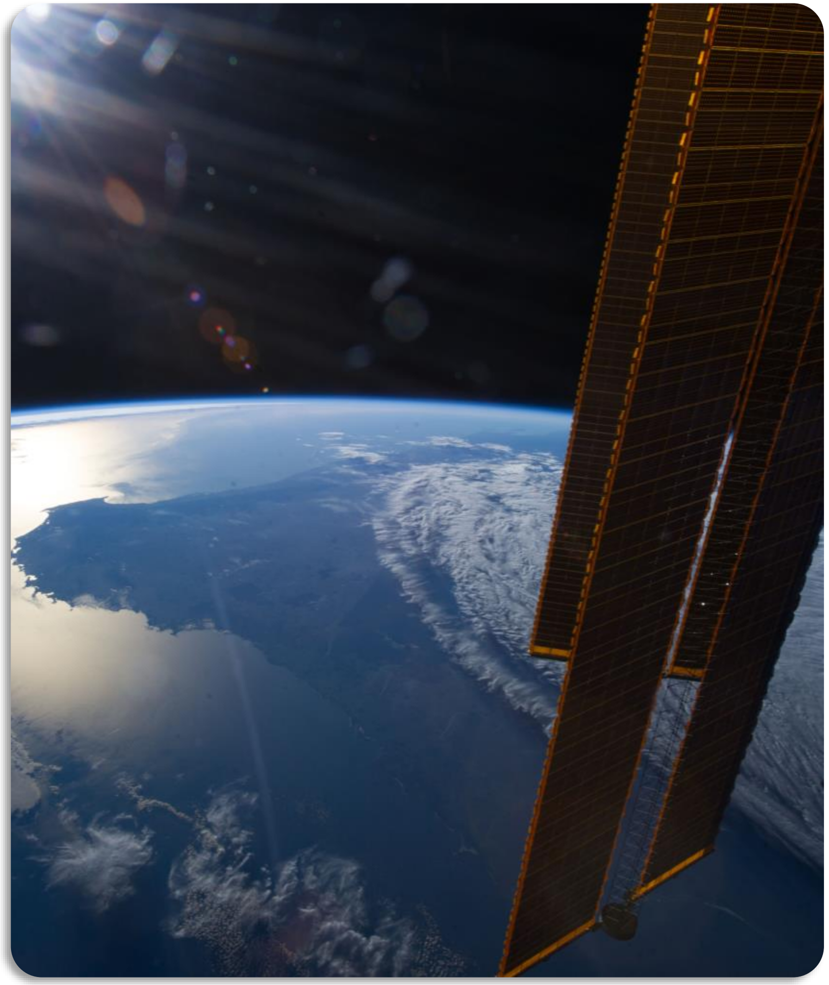

Future Work

- Integrate and test seamless signal processing into web-application backend
- Integrate and test signal processing GUI

THANK YOU

Questions?