INCA

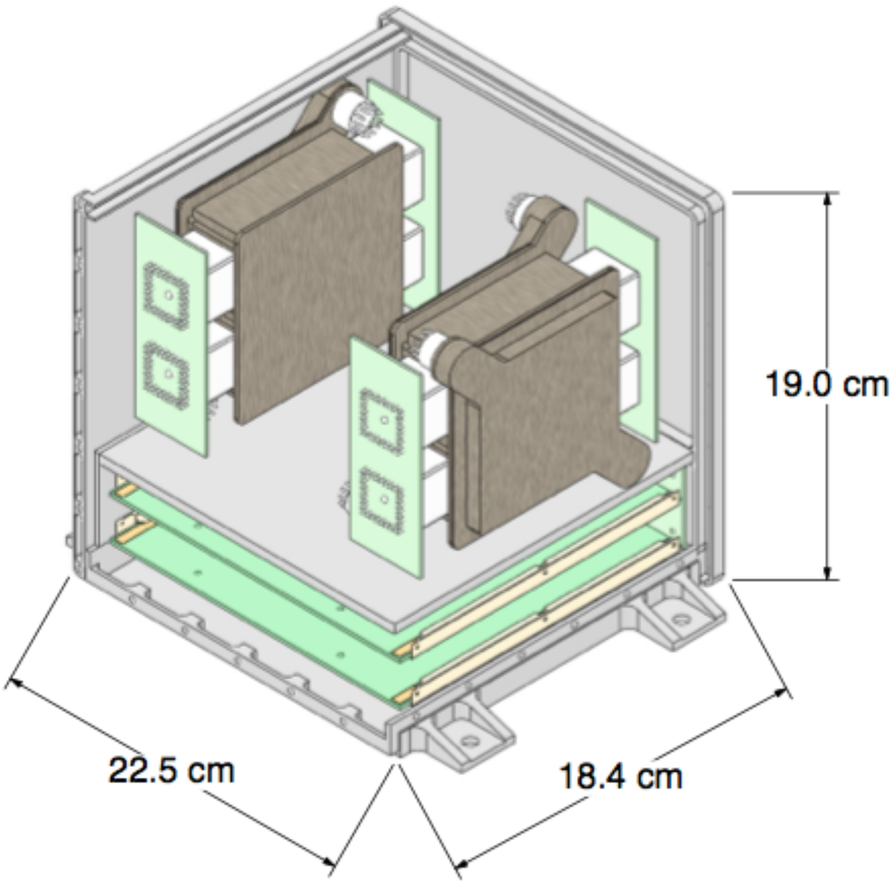
Ionospheric Neutron
Content Analyzer

New Mexico
State University
University NanoSat-8

CubeSat Workshop
Presentation
August 2, 2014; Logan, UT

Presentation Outline

- Mission Overview
- Mission Relevance
- ConOps
- INCA Payload
- Subsystem Design
- Thanks & Questions



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INCA – A Collaboration

- **AFRL Space Weather Center of Excellence**
  - Contacts: S. White, R. S. Selesnick
  - Space Weather Forecasters are the Prime Customer

- **NASA Goddard Space Flight Center**
  - Contacts: Eric Christian, Georgia de Nolfo
  - Payload Instrument Support & Testing

- **University of New Hampshire**
  - Contacts: James Ryan, Peter Bloser
  - Payload Instrument Primary Provider

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Mission Overview

- **Project Objectives**
  - Design and fabricate a small satellite that fulfills the design constraints of the University NanoSat Program and supports the requirements of the UNH Neutron instrument.
  - Provide professional engineering quality design while maintaining educational responsibilities.

- **Mission Objectives**
  - PRIMARY: To demonstrate the functionality of Scintillator/SiPM-based neutron spectrometer in Low Earth Orbit.
  - SECONDARY: To gather neutron flux data and corresponding latitude metadata from at least three latitudinal zones.
  - TERTIARY: To detect a primary solar neutron event.

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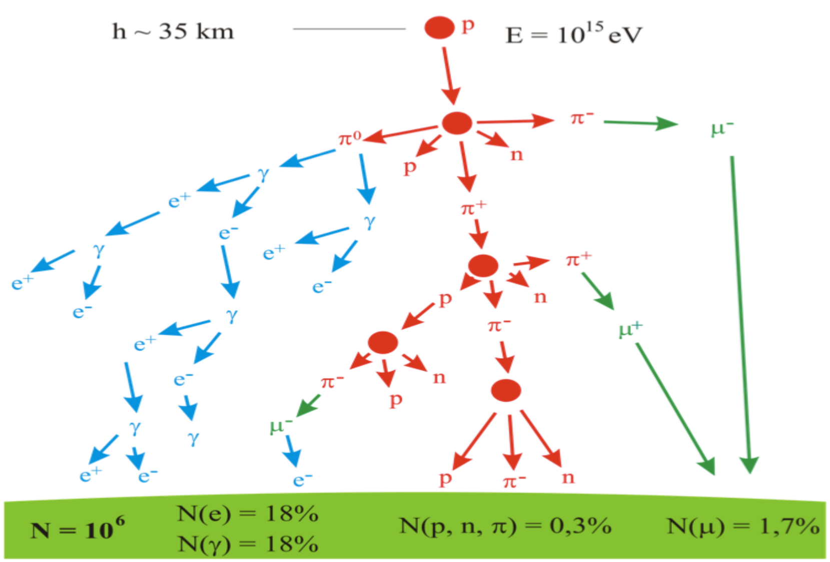
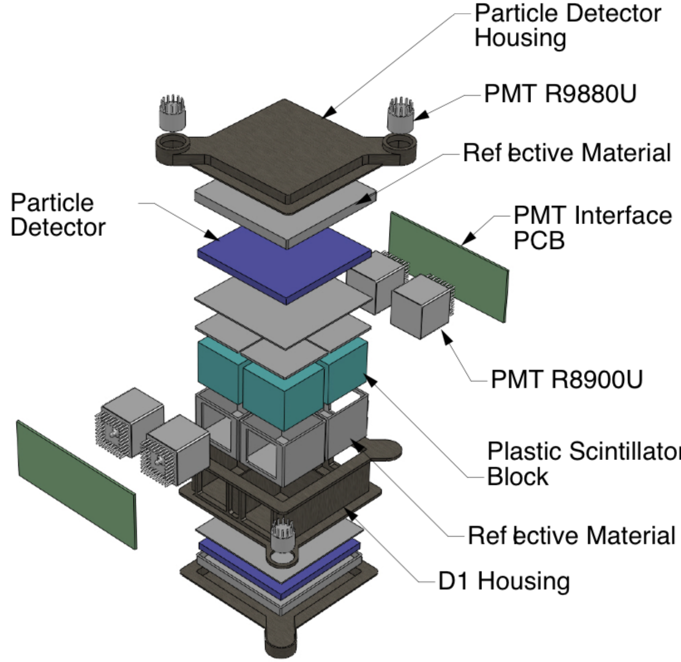
Atmospheric Neutrons

- **Neutron Sources**
  - Air Shower Neutrons
  - Albedo Neutrons
  - Solar Neutrons





- **Payload Detector**
  - Scintillators & SiPMs
  - Solid Angle
  - Time Stamping
  - GPS Stamping

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Mission Relevance

AFRL's Space Weather Center of Excellence

- Mitigate effects of space environment on systems
- Robustness depends on validation of physical observations.

NASA Science Directorate

- Atmospheric Composition Modeling and Analysis Program (ACMAP)

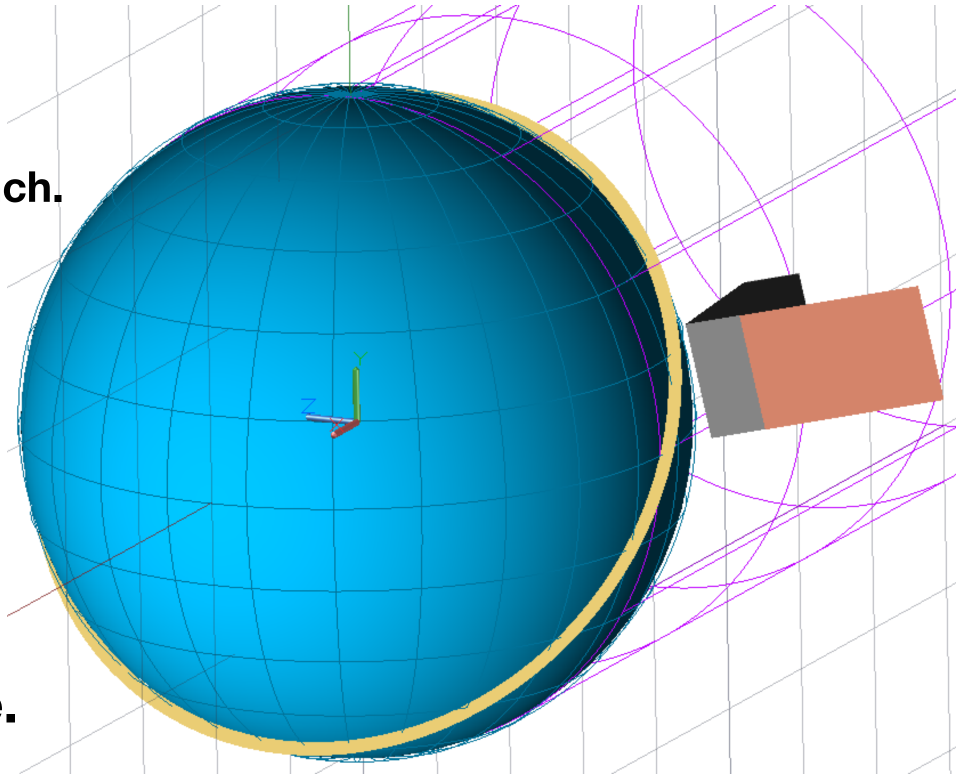
INCA will enhance the robustness of Space Weather models by adding measurements of the neutron spectrum observed in LEO.

Key Measurement Reqs.

Measurement Requirement	Range/Value	Source of Req.
The UNH Instrument shall measure the flux of neutrons in a certain energy range.	1MeV – 20MeV	Customer Proposal
The UNH Instrument shall measure a minimum number of neutron events.	20	MO 1/Uncertainty Calculation
	300	MO 2/Uncertainty Calculation
The UNH Instrument shall be pointed at the Sun with a certain accuracy.	+/- 10 degrees	Customer Q&A
The orientation Metadata (from ADC) shall have a certain accuracy.	+/- 2 degrees	Customer Q&A
The UNH Instrument shall be monitored with sensors to generate housekeeping data.	20 voltage monitors, 20 current monitors, 3 temperature sensors	MO 1/Customer Q&A
The longitudinal Metadata (from ADC) shall be gathered by GPS accurate within a certain degree of latitude.	1 Degree	MO 2/MO 3/Customer Q&A

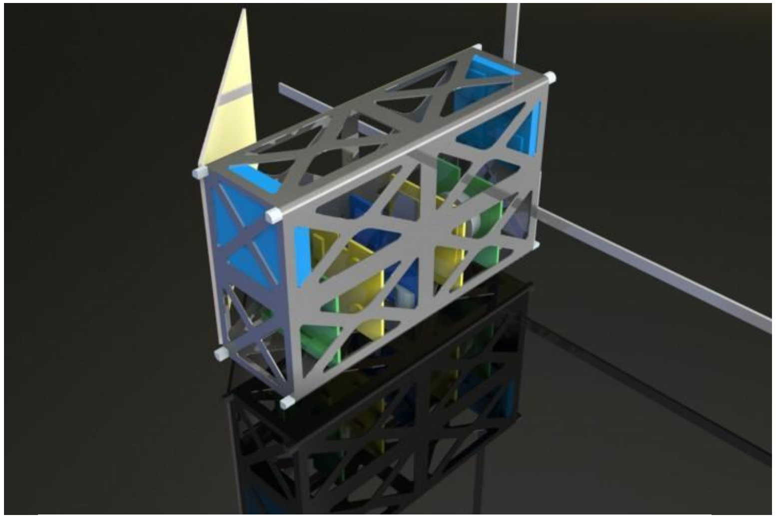
Concept of Operations

- Launch Sequence.
  - Launch Vehicle Ascends.
  - Eject from Launch Vehicle.
  - Deploy Solar Panel upon launch.
  - Deploy Antennas.
- 45-Minute Sleep Period.
- Activation Sequence.
  - System Check.
  - First Transmission.
  - Detumble & Point.
  - Charge Batteries.
- Science Mission Sequence.
  - Record Data, Metadata.
  - Transmit Data, Metadata.
  - Repeat.
- End of Life Sequence.

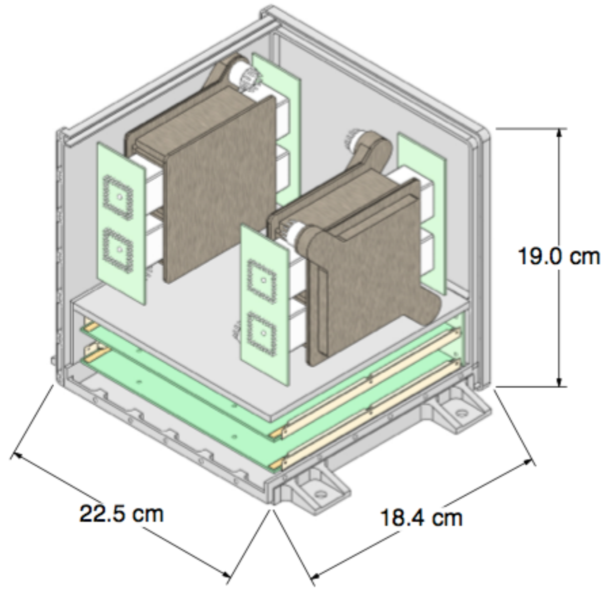


INCA Spacecraft Overview

- **The Basics**
  - 6U (30cm x 20cm x 10cm) Structure
  - Planetary Systems Corp. Standard
  - Mainly COTS Parts in Preliminary Design
  - KISS



- **The Payload**
  - Being adapted from Solar PRobe Ion Neutron & Gamma-ray Spectrometer (SPRINGS) design
  - Bus and Payload design happening side-by-side
  - Pointed in same direction as Solar Array



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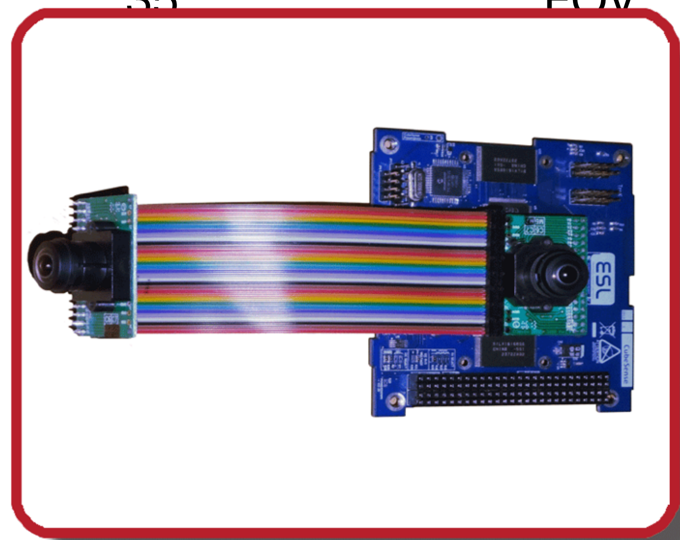
ADC Subsystem Design

Attitude Determination

ISIS CubeSense

Accuracy :

◦Nadir: 0.18° (where Earth is completely visible in field-of-view)
<0.5° over ± 35° FOV
<2° over ± 45° FOV
◦ Sun:
<0.3° over ±
<1° over ±
<1.85° over ± 90° FOV



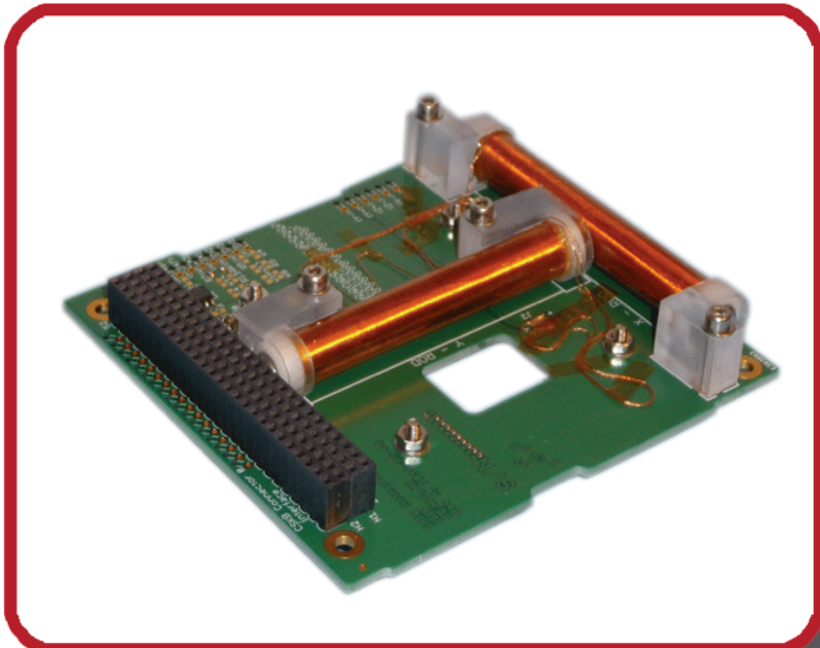
Product Properties

- Power: 360mW max, <100mW avg
- Size: 96mm, 91mm, 10mm (excluding cameras)
- Mass: 110g (including cameras)
- I2C and UART interface available

ADC Subsystem Design

Attitude Control

ISIS Magnetorquer Board



Performance

- Actuation level
    - Max: 0.24 Am^2 (@ 20°C, 5V)
- Power consumption (@ 20°C)
    - Torque rods: ~1 Watt/Am^2
    - Air core: ~2 Watt/Am^2

Properties

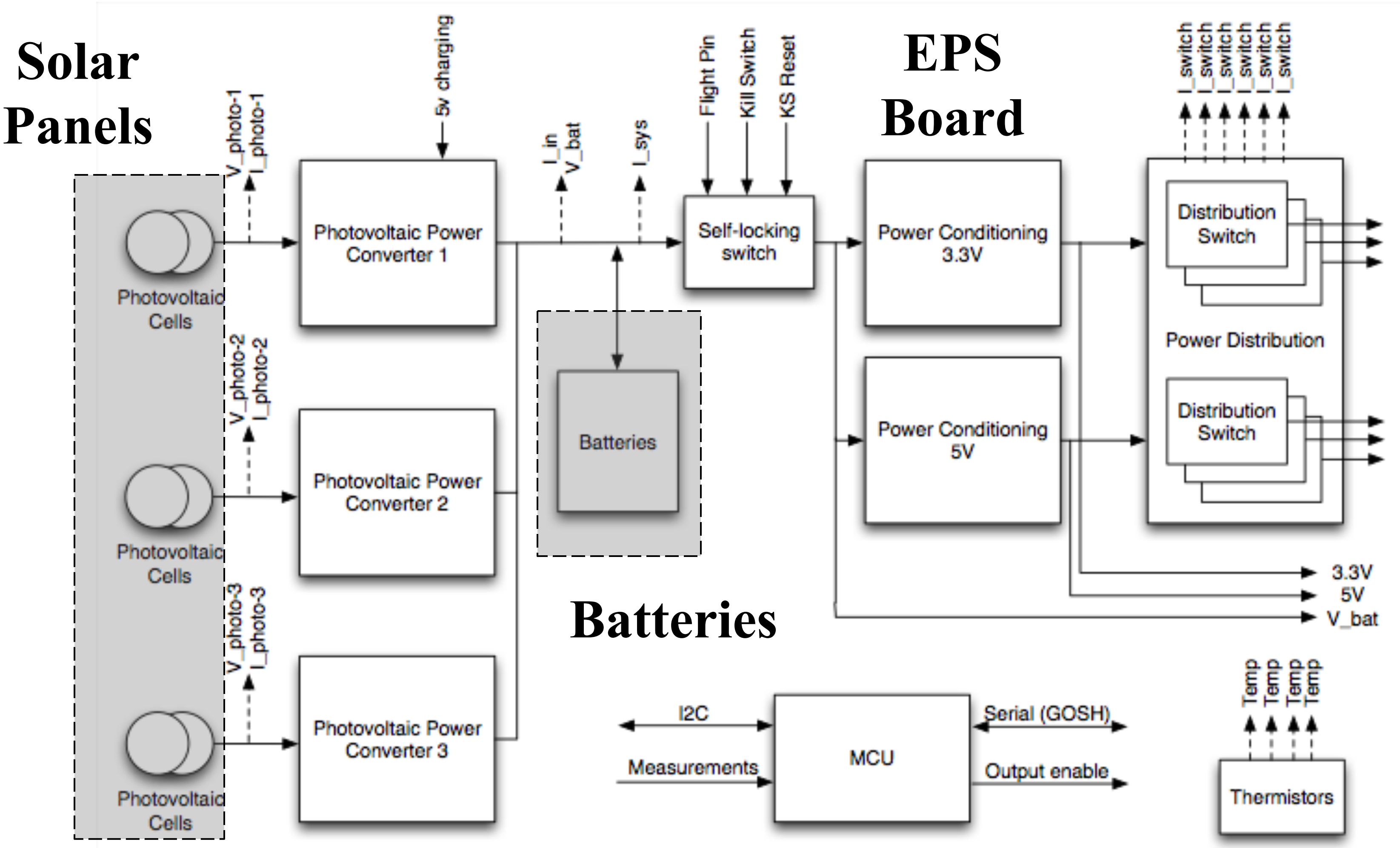
- Two torque rods and one air core torquer
- Mass: ~195 grams
- Operational temperature range: -40 to +70°C
- Dimensions: 95.9 x 90.1 x 15 mm^3
- Supply voltage
    - Actuation: 5V

EPS Requirements

- **Major Driving Requirements**
  - Shall harvest solar energy using a solar panel
  - Shall convert harvested solar energy to electrical power
  - Shall charge onboard batteries during sun exposure
  - Shall use battery power during orbital eclipses
  - Shall distribute current at the required voltage to each respective system
  - Shall regulate distributed current at the required voltage appropriate to each system

- **Verification Methods**
  - Testing and simulation for
    - Solar Panels
    - Battery

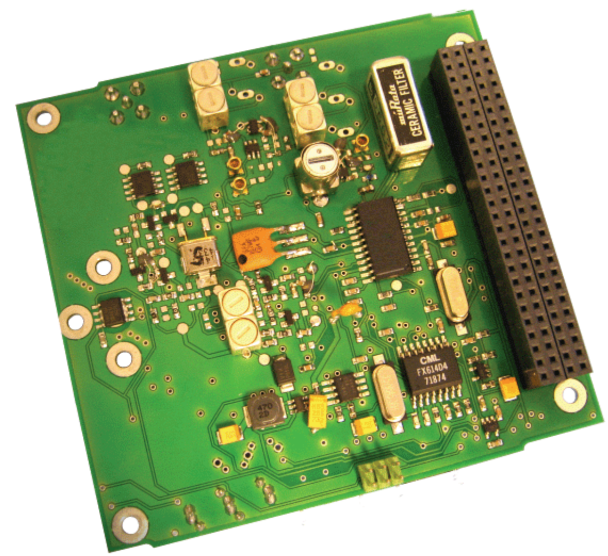
EPS Subsystem Design



COM Requirements

- **Major Driving Requirements**
  - Transmit PAY Data/Metadata to ground station
  - Receive commands from ground station
  - Observe required radio silence window
  - Maintain a +6dB link margin for both uplink & downlink
  - Maintain system compatibility with ground station

- **Verification Methods**
  - Link and Data Budgets
  - Simulations (STK)
  - FlatSat Mock-Up
  - Individual Subsystem Testing



CDH Subsystem Design

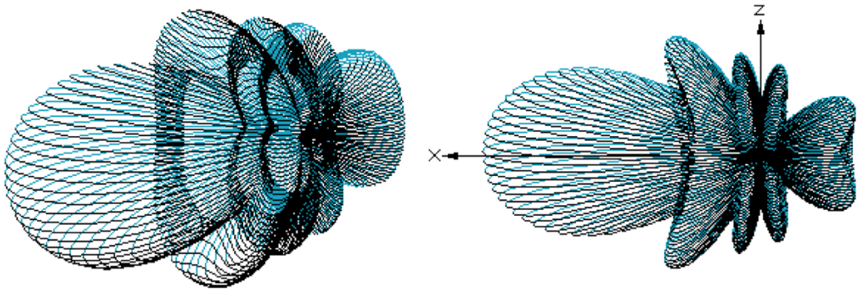
- **Hardware**
  - GOMSpace NanoMind A712C
  - 32-bit ARM7 RISC CPU
  - 40 MHz Clock
  - 2 GB MicroSD Slot
  - Numerous I/O: I2C, UART
  - Temperature Sensors
  - Flight Heritage

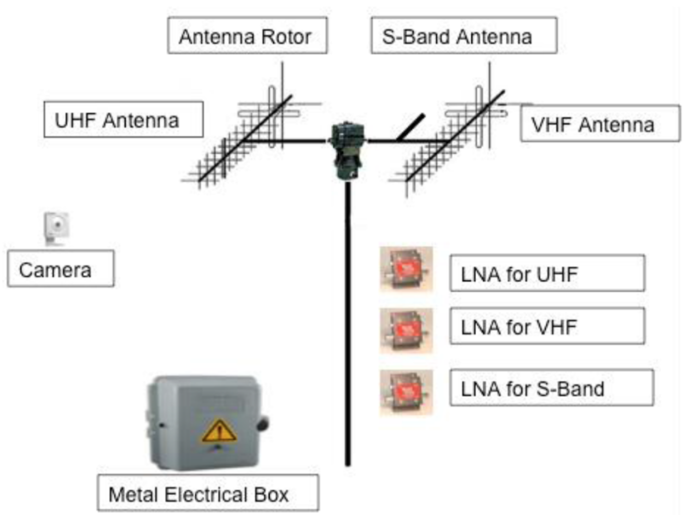
- **Software**
  - Embedded Linux
  - Included Device Drivers
  - Programmed in Linux & C

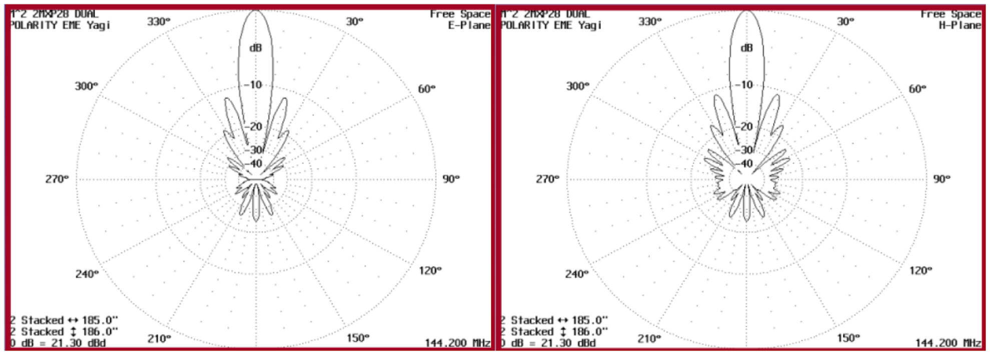
NMSU Ground Station

- **Major Driving Requirements**
  - Track INCA Spacecraft
  - Send commands to INCA Spacecraft
  - Receive acknowledgments, PAY Science Data & Metadata, and housekeeping data from INCA Spacecraft
- **Verification Methods**
  - Practical Tests with COM Subsystem
  - Practical Tests with FlatSat Mock-Up
- **Ground Station**
  - NMSU EE Dept. Senior Capstone Project
  - Taylor Burgett KF5UIP
  - Status

Ground Station Design

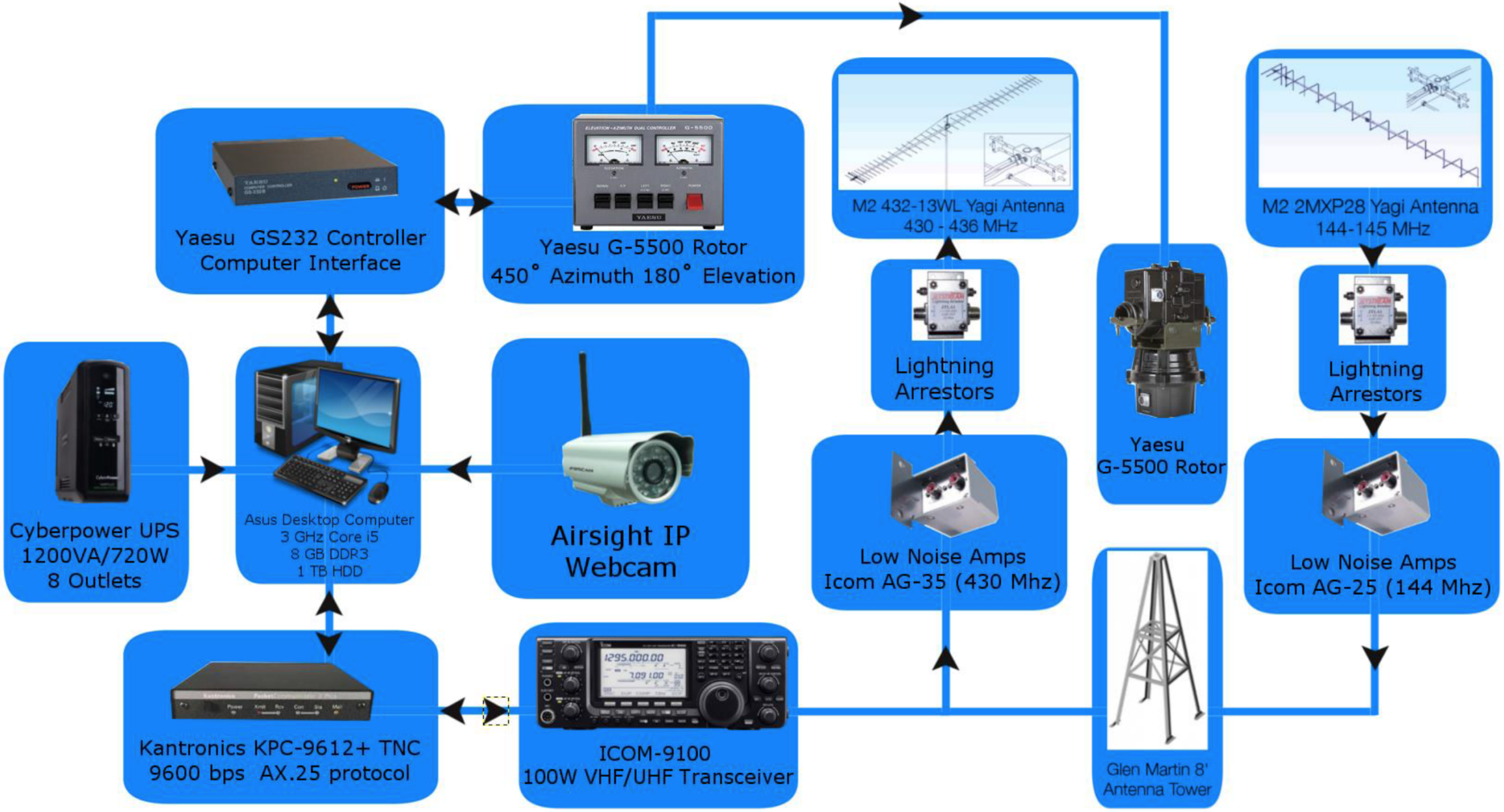






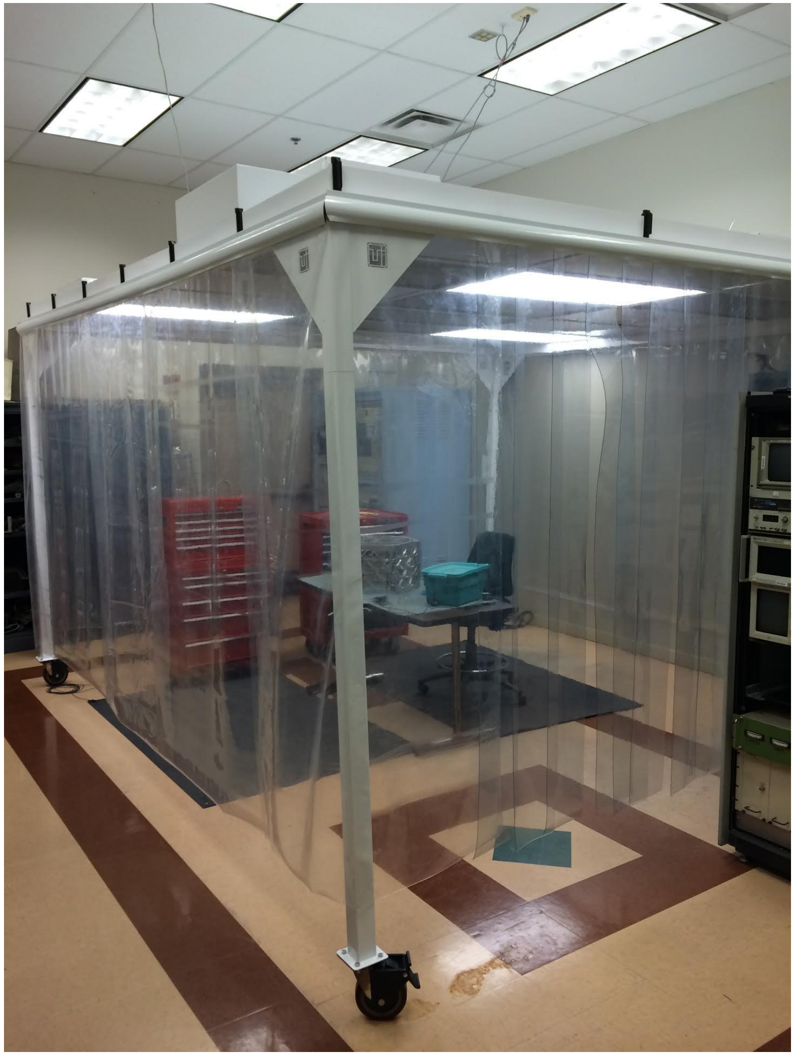
- Support directional Yagi antennas.
- Full sky, computer controlled azimuth/elevation antenna rotator.
- Weather proof connections (Tape/Tar)
- Antennas rated to 100 mph winds.

Block Diagram



AIR FORCE RESEARCH LABORATORY

Cleanroom & Lab



Thanks & Acknowledgments

- Monetary Support
  - New Mexico Space Grants Consortium
  - Harris Corporation
- NMSU Organizations
  - Physical Sciences Lab
  - Industrial Engineering Dept.
- Special Thanks to
  - Dr. Steve Stochaj
  - Mr. Bob Hull
  - Sue, Grace, & Annette
  - Dr. Jeanine Cook
  - Dr. Jim Ryan
  - Dr. Peter Bloser
  - Dr. Georgia de Nolfo
  - Ms. Patricia Sullivan
  - Dr. William Godwin
  - Mr. Brian T. Sanders

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