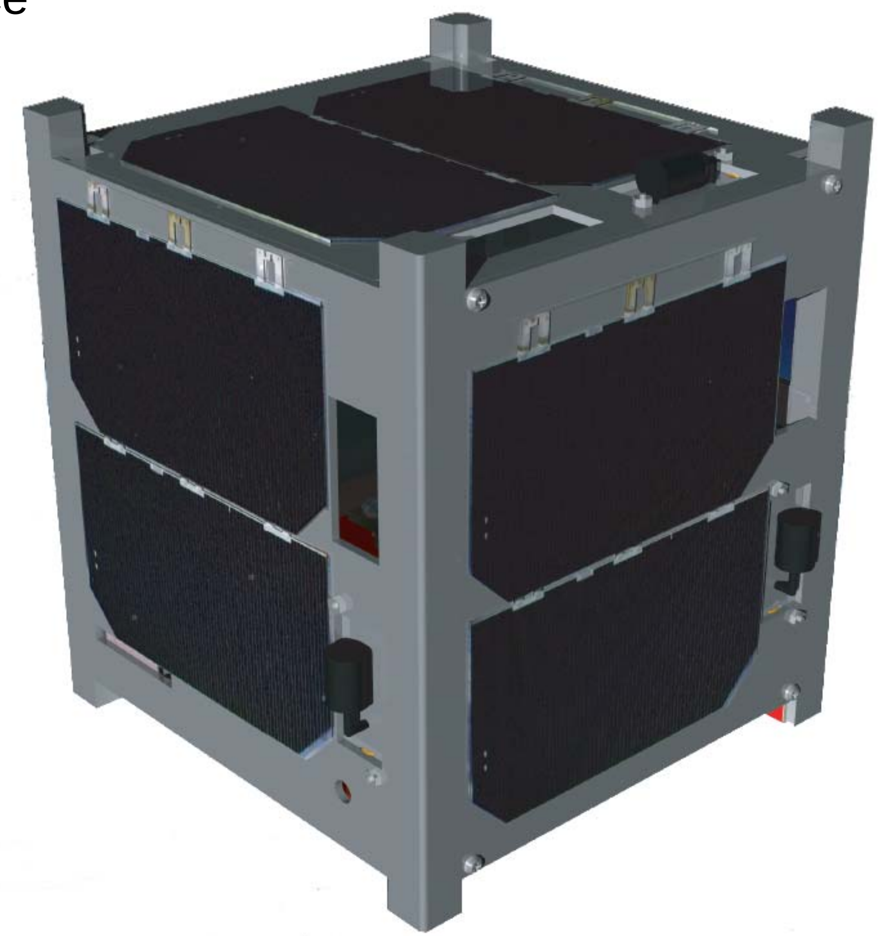
Auburn University

Student Space Program

AubieSat-1: Auburn's First Student–Built Satellite
for Scientific Experiments in Space



Faculty-advisor: Dr. J. M. Wersinger
(Department of Physics)

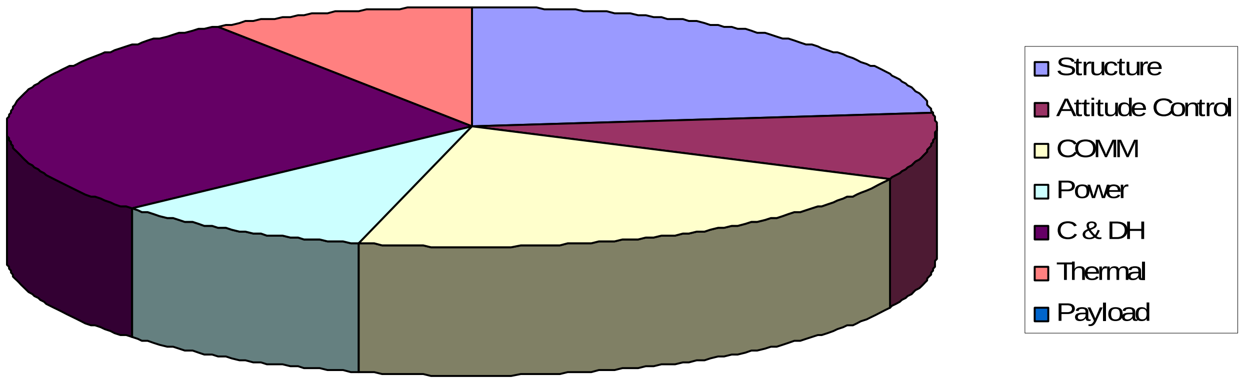
Mentor: Mr. Cook (Former Lockheed Engineer)

Presenter: Eric Grimes

Mission

- Mission statement:
  - To build a satellite for scientific experiments in space.
- Primary objective:
  - To successfully communicate data collected in space to the ground
- Secondary objectives:
  - To successfully record measurements from a new ultra-violet (UV) sensor
  - To provide a documentation architecture for future small satellites

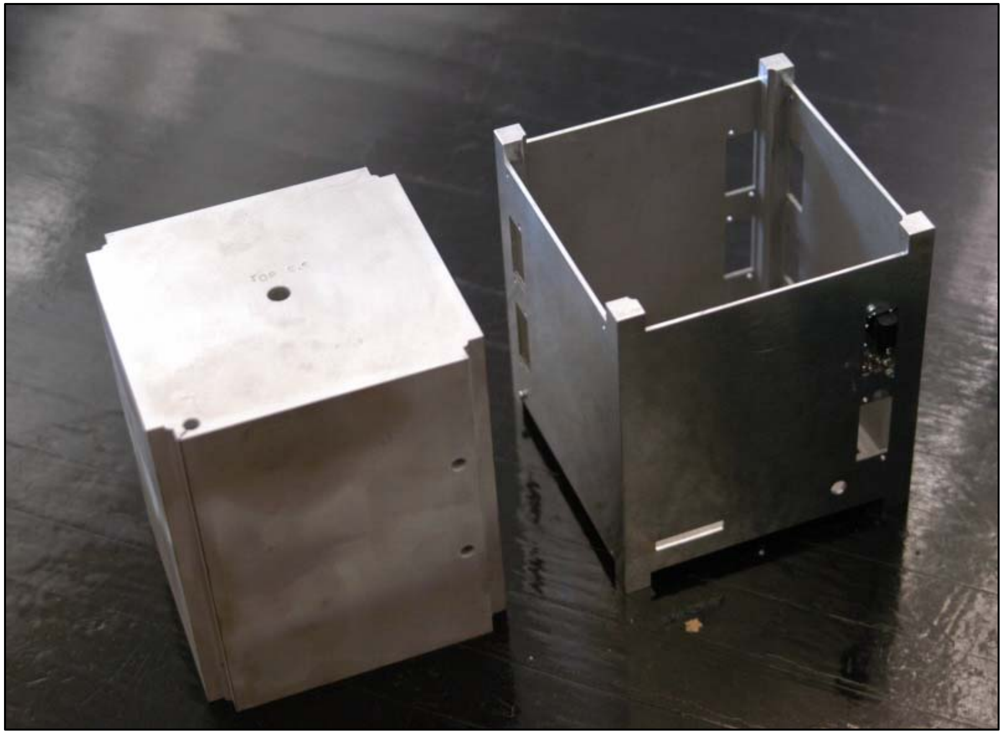
Cost Budget



Subsystem	Current Cost (USD$)
Structure	$750.00
Attitude Control	$300.00
Communications	$700.00
Power	$300.00
Command & Data Handling	$900.00
Thermal	$300.00
Payload	$0
Total	X 30% = $6500.00

Structure

- ❖ Requirements:
  - ➢ Dimensions: 10cm x 10cm x 10cm
  - ➢ Target mass: 1.00 kg
- ❖ Hard anodized 7075 Aluminum machined from solid block using EDM (Electrical Discharge Machining)
  - ➢ Advantage: Structurally sound
  - ➢ Disadvantage: Expensive
- ❖ Scotchweld 2216 epoxy for attaching solar cells
- ❖ Antennas made with Nitinol



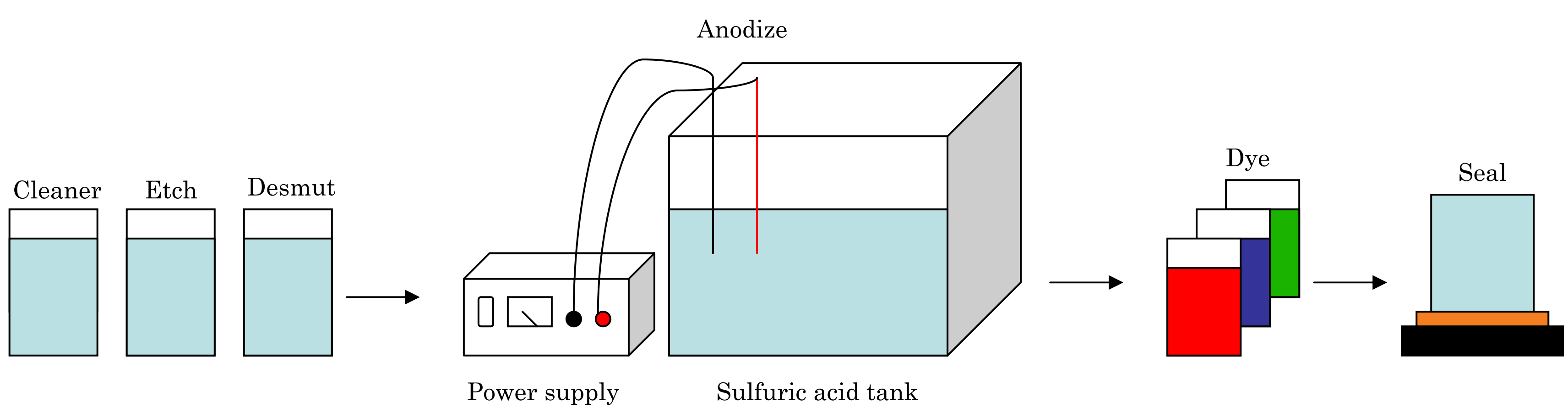
Anodizing Process

- ❖ The problem: The 7075 Aluminum material is extremely vulnerable to the harsh environment of space

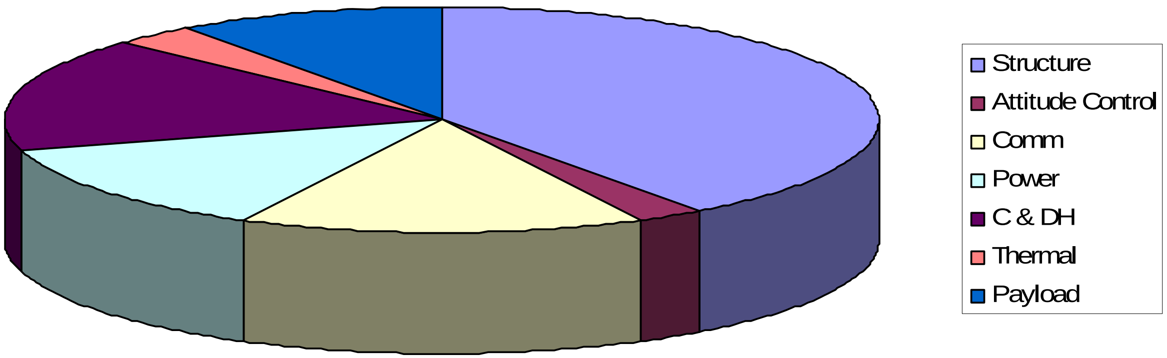
- ❖ The solution: Anodize the structure

- ❖ What is anodizing?
  - ➢ Electrochemical process that thickens and toughens the naturally occurring protective aluminum oxide

- ❖ How exactly does it help?
  - ➢ Strengthens the aluminum
  - ➢ Prevents corrosion and abrasion



Mass Budget



Subsystem	Allocated Mass (g)	Current Mass (g)
Structure	400	378
Attitude Control	75	25
Communications	150	46.5
Power	130	102
Command & Data Handling	165	60
Thermal	30	15
Payload	50	~10
Total	1000	636

MicroGravity Test

- ❖ First CubeSat to be microgravity tested
- ❖ Test scheduled for May 3rd – May 13th
- ❖ MEMS accelerometers, gyros and video analysis to study the deployment of cubes for a range of configurations

Image courtesy of Johnson Space Flight Center

Orbital Parameters

❖ Low Earth Orbit (LEO)

❖ Sun-synchronous

❖ Inclination: 98°

❖ Altitude: 820 km

❖ Orbit period: 98 minutes

❖ Advantage: Steady solar energy supply

❖ Disadvantage: South Atlantic Anomaly

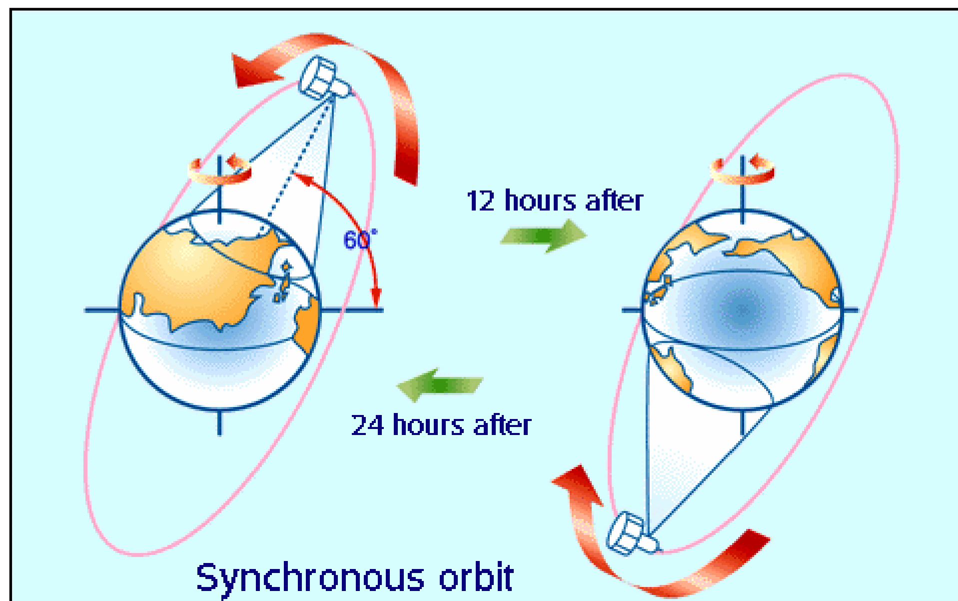
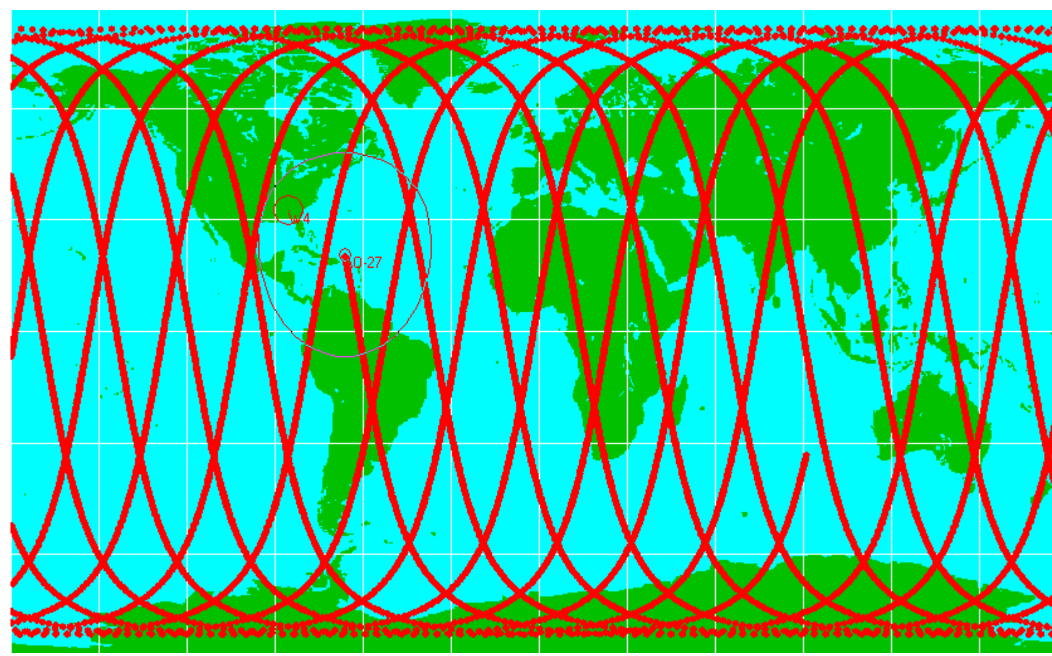


Image by the National Space Agency of Japan (NASDA)

Orbital Simulation

- ❖ WinOrbit tracking software
- ❖ Simulation on an existing satellite (AMRAD-OSCAR-27) with similar orbital parameters:
    - ➢ Low Earth Orbit
    - ➢ Sun-synchronous
    - ➢ Inclination: 98°
    - ➢ Altitude: 800 km



Path of the AO-27 over 24 hours

Simulation, cont.

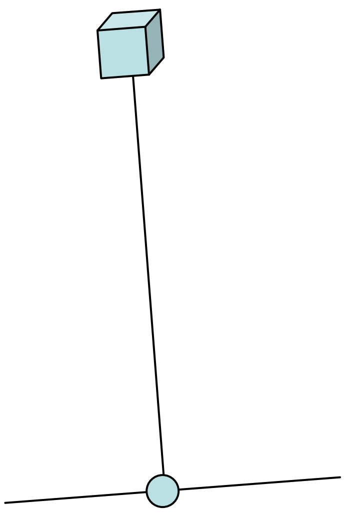
April 21			April 22		
AOS	LOS	Access time	AOS	LOS	Access time
1:18:00 AM	1:33:00 AM	15 min	12:50:00AM	1:05:00 AM	15 min
3:01:00 AM	3:10:00 AM	9 min	2:31:00 AM	2:44:00 AM	13 min
12:01:00 PM	12:05:00 PM	4 min	1:09:00 PM	1:23:00 PM	14 min
1:36:00 PM	1:51:00 PM	15 min	2:48:00 PM	3:02:00 PM	14 min
3:16:99 PM	3:29:00 PM	13 min			
11:16:00 PM	11:23:00 PM	7 min			
	Total:	**56 min**		**Total:**	**56 min**

April 23			April 24		
AOS	LOS	Access time	AOS	LOS	Access time
12:24:00 AM	12:37:00 AM	13 min	1:35:00 AM	1:50:00 AM	15 min
2:03:00 AM	2:17:00 AM	14 min	3:20:00 AM	3:26:00 AM	6 min
12:42:00 PM	12:54:00 PM	13 min	12:16:00 PM	12:25:00 PM	9 min
2:21:00 PM	2:36:00 PM	15 min	1:53:00 PM	2:08:00 PM	15 min
4:03:00 PM	4:10:00 PM	7 min	3:34:00 PM	3:45:00 PM	11 min
11:57:00 PM	12:10:00 AM	13 min	11:31:00 PM	11:41:00 PM	10 min
	Total:	**75 min**		**Total:**	**66 min**

- Average total access time per day: 62 min
- Total access time per access: 11.5 min

Attitude Control

- ❖ Purely Passive control
- ❖ Dampened gravity gradient boom
  - ➢ 10° controlling accuracy
- ❖ Use solar cells to determine which side is sun-normal (for payload)
- ❖ The boom will be constructed of Nitinol and will be part of the antennae



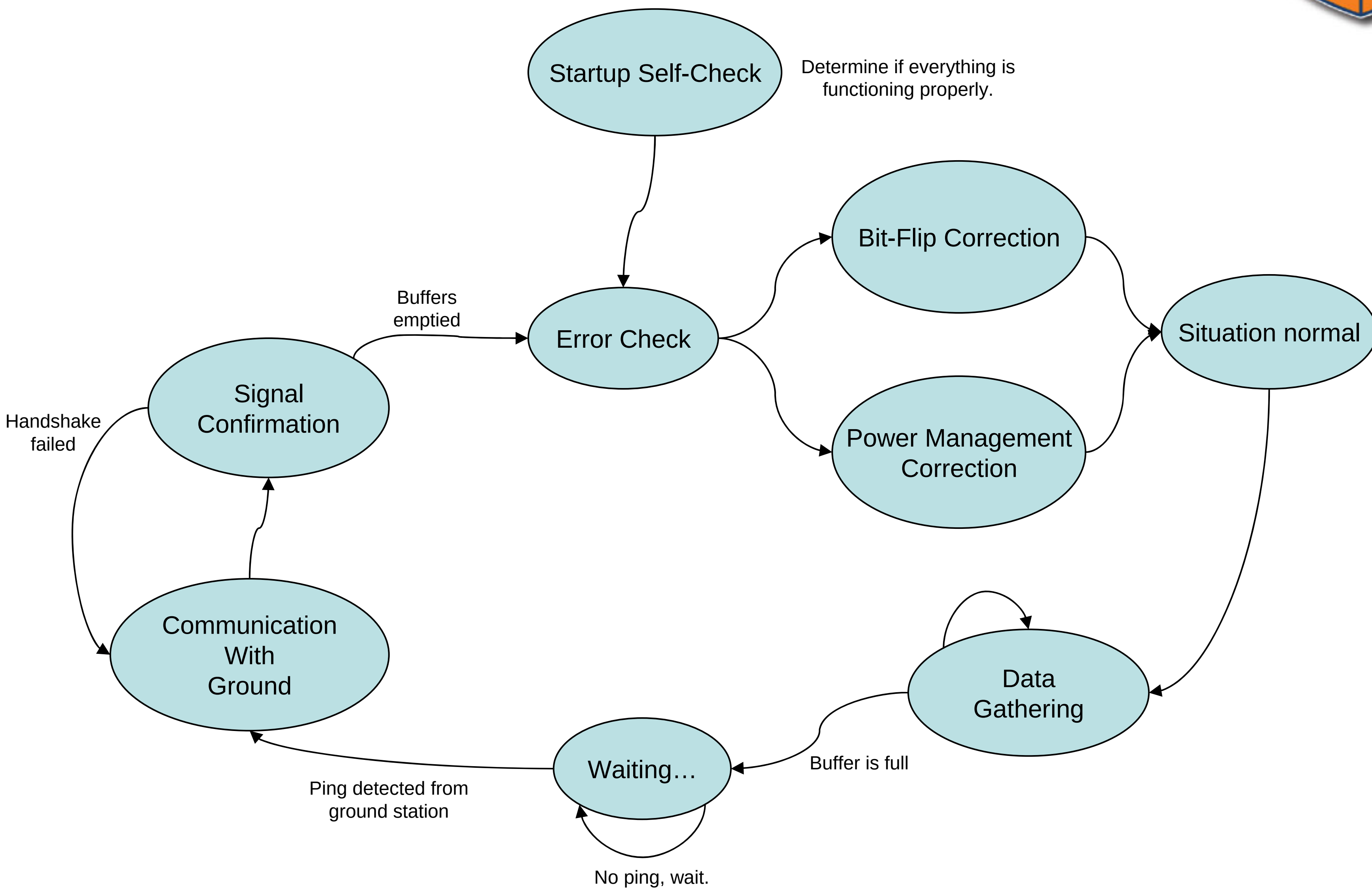
Command & Data Handling

- "Brains" of the CubeSat
  - Read voltage across the payload (UV sensor)
  - Monitor thermal conditions using thermistors
  - Send collected data to the TNC for sending to ground station
- Reconfigurable FPGAs
  - Protects against single event upsets caused by radiation
- Current status:
  - Programming / testing a development FPGA
  - Trade studies on different FPGAs

FPGAs

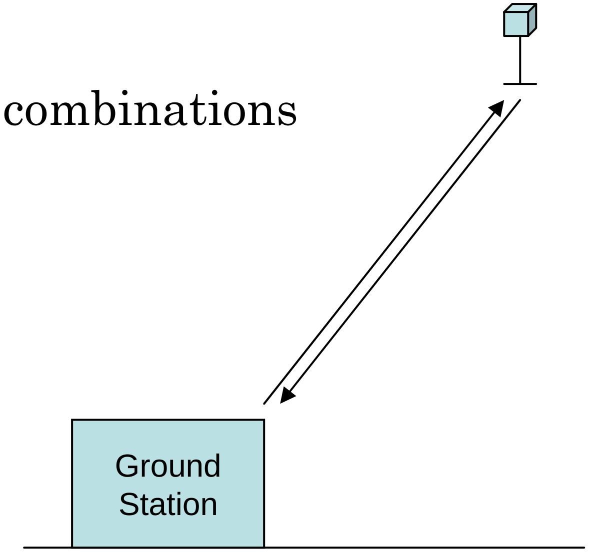
- Reconfigurable Field Programmable Gate Arrays (FPGAs):
  - Configuration memory can be read and rewritten without effecting operation
  - Allows hardware design to be changed easily in-flight
  - Relatively low cost
  - Capable of detecting and correcting single event upset (SEU) errors caused by high-energy particles hitting critical nodes
  - Prevent single event latch-ups (SEL) by using industrial FPGAs. (Radiation hardened)

Basic FPGA State Diagram



Communications

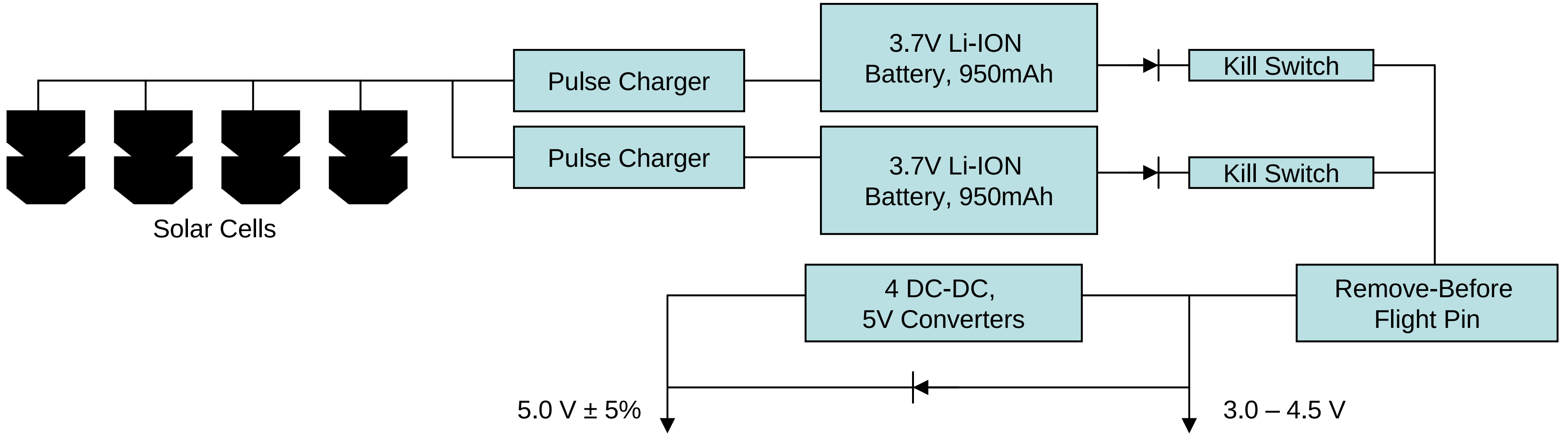
- ❖ Purpose:
  - ➢ Get the results of the experiments from the satellite to the ground
- ❖ To accomplish this:
  - ➢ C&DH sends collected data to a terminal node controller (TNC)
  - ➢ The TNC formats the data and sends it to the transceiver
  - ➢ Transceiver uses the antenna to transmit and receive data
- ❖ Uplink/Downlink frequency: 440 MHz
- ❖ Current status:
  - ➢ Researching / testing transceivers and antenna combinations



Power

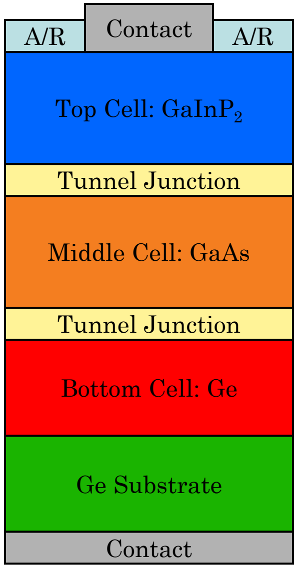
- (2) ULTRALIFE Lithium ION Rechargeable batteries
  - Average Voltage: 3.7 V
  - Capacity: 950 mAh
  - EOL efficiency: 80%
  - Specific energy storage: 10.1 kJ
  - Total energy storage: 20.2 kJ

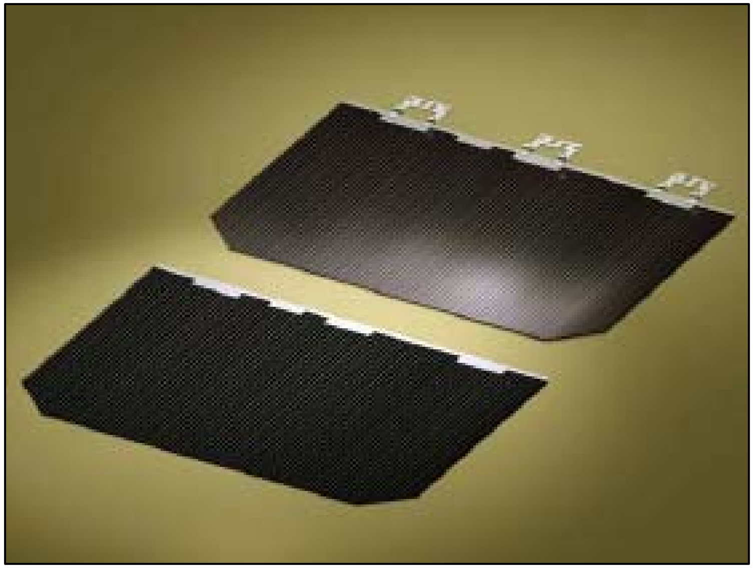
- (2) MAX1879EUA single-cell Lithium-ION (Li+) pulse chargers
- Functional Block Diagram:



Solar Cells

- Spectrolab's 26.8% Improved Triple Junction (ITJ) Solar Cells
- Solar Cell Structure: $GaInP_2/GaAs/Ge$
- Advantages:
  - Beginning of life (BOL) efficiency: 26.8%
  - End of life (EOL) efficiency: 22.3%
  - Space-qualified and flight heritage in low earth orbit environments
- Disadvantages:
  - Very brittle
- Area: 25 cm² each





Environment

- Radiation
  - South Atlantic Anomaly
  - 1.5mm Al shielding will block most electrons below 1MeV and protons below 10MeV
  - AubieSat-1's solar cell makeup of $GaInP_2/GaAs$ provide increased radiation hardness over other cells

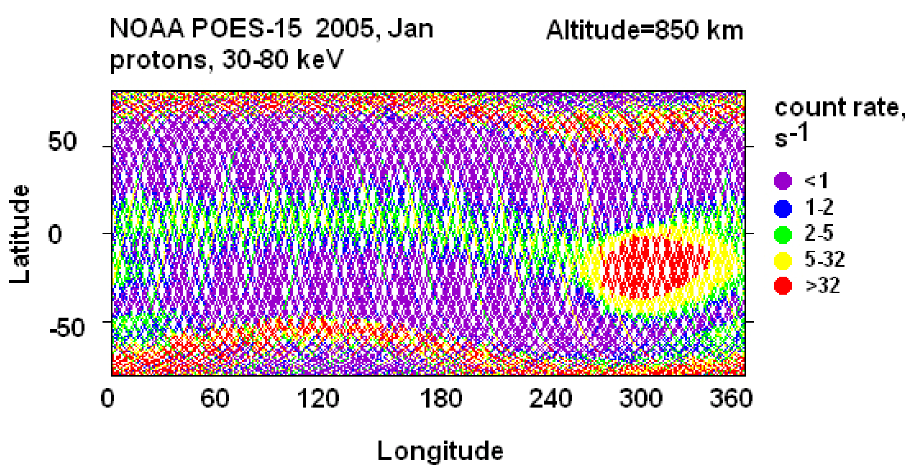


Image by the National Oceanic and Atmospheric Administration

Thermal

- Harsh thermal environment
  - Temperatures can range from -200°C to 100°C at any given time
- Purpose:
  - To keep all of AubieSat's components and structural elements within their operational limits at all times
  - To report component temperatures to ground station
- Thermal modeling / simulation
  - ANSYS Workbench
  - Steady-state and transient analysis
- Thermistors
  - YSI 44000 series

Ground Station

- ❖ Requirements:
  - ➢ Transmit commands to AubieSat-1
  - ➢ Receive data from AubieSat-1
  - ➢ Process and report received data
- ❖ Tracking of AS-1:
  - ➢ Based on Keplerian elements provided by NORAD
  - ➢ Standard NORAD/NASA Two-Line Element (TLE) format

Image of NORAD's operating center

Payload

- New type of Ultra-Violet (UV) Sensor
  - Currently being designed by graduate students in the Auburn University Physics department

- Objectives:
  - Measure the voltage across the sensor both exposed to the sun and not exposed outside of the atmosphere
  - Report results to ground station

- Secondary Objective:
  - Monitor how the sensor degrades over time

Questions?

- Contact Information:
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