

GreenCube and RocketCube

Student Projects

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Dartmouth College

CubeSat Developer's Summer Workshop

Utah State University, Logan, Utah

August 9, 2009



Lynch Rocket Lab

Who We Are:

DARTMOUTH COLLEGE

Department of Physics and Astronomy

Wilder 317 Lab Group

- Prof. Kristina Lynch - Principal Investigator
- Amanda Slagle - GreenCube Manager (Undergraduate)
- Phillip Bracikowski - RocketCube Manager (Graduate)

2 Faculty

3 Department Engineers

14 Students

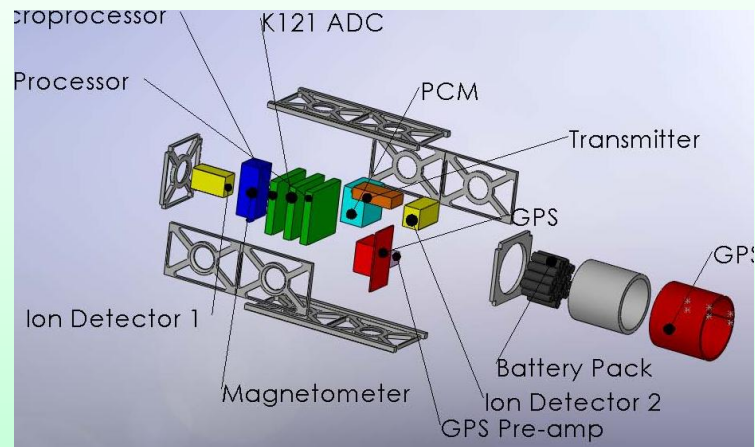
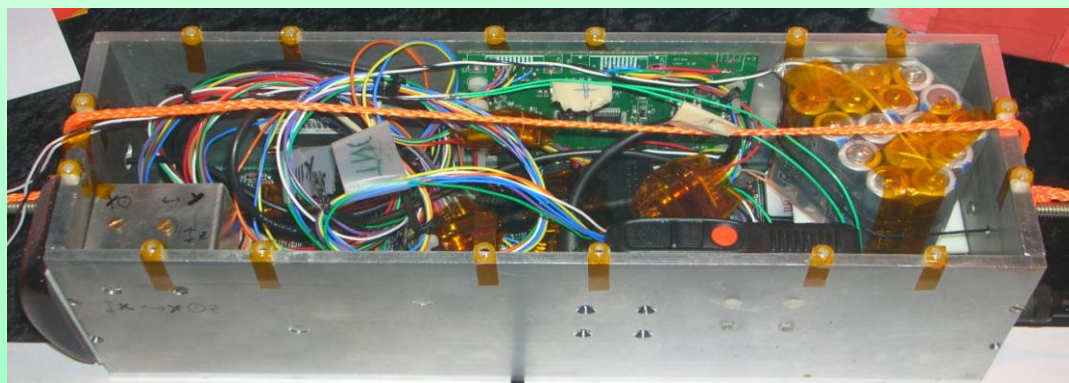




Our Projects

GreenCube Fall 2007 - Now

- High Altitude Balloon 3U CubeSat 0-30Km
- Undergraduate Designed and Managed



RocketCube Fall 2008 - Now

- Sub-Orbital 3U CubeSat 100-400km
- Graduate Designed and Managed



Lynch Rocket Lab

Why GreenCube and RocketCube?

Purpose: Development of **Autonomous Low-Resource Sensor Craft** for **Multi-Point Auroral Plasma Science Missions**

- Training the next generation of Students and Researchers
- Development of new in-house capabilities

Sponsorship Provided by:

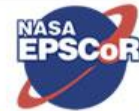
- Jet Propulsion Laboratory GreenCube II Grant
- State of New Hampshire - NASA EPSCoR Grant



JPL
Jet Propulsion Laboratory
California Institute of Technology



New Hampshire NASA EPSCoR
Experimental Program to Stimulate Competitive Research



Presentation Outline

- GreenCube
 - Flight 0
 - Flight 1
 - Flight 2
- RocketCube
 - Purpose
 - Components
 - Systems
 - Future



Presentation Outline

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Flight 0: Prototype Flight

June 2008

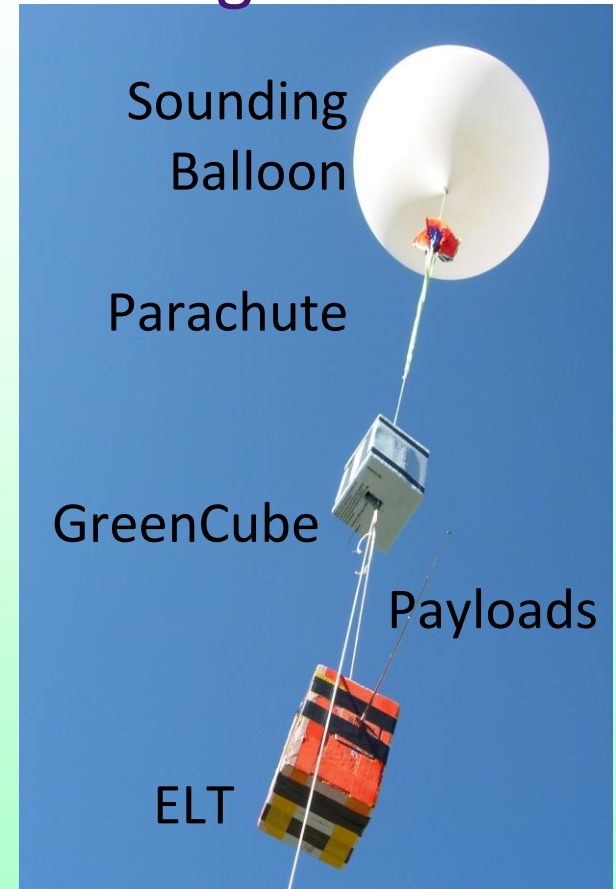
Telemetry System

- OTS 2m amateur radio (Yaesu VX-3R)
- OTS APRS/KISS packet TNC (Argent Tracker2)
- OTS Garmin GPS 15H

Flight Train

- Kaymont Sounding Balloon
- Emergency Locator Transmitter (ELT)

Flight Train



Flight Path



Telemetry Reported

- Lat., Long., Altitude
- Internal Temperature

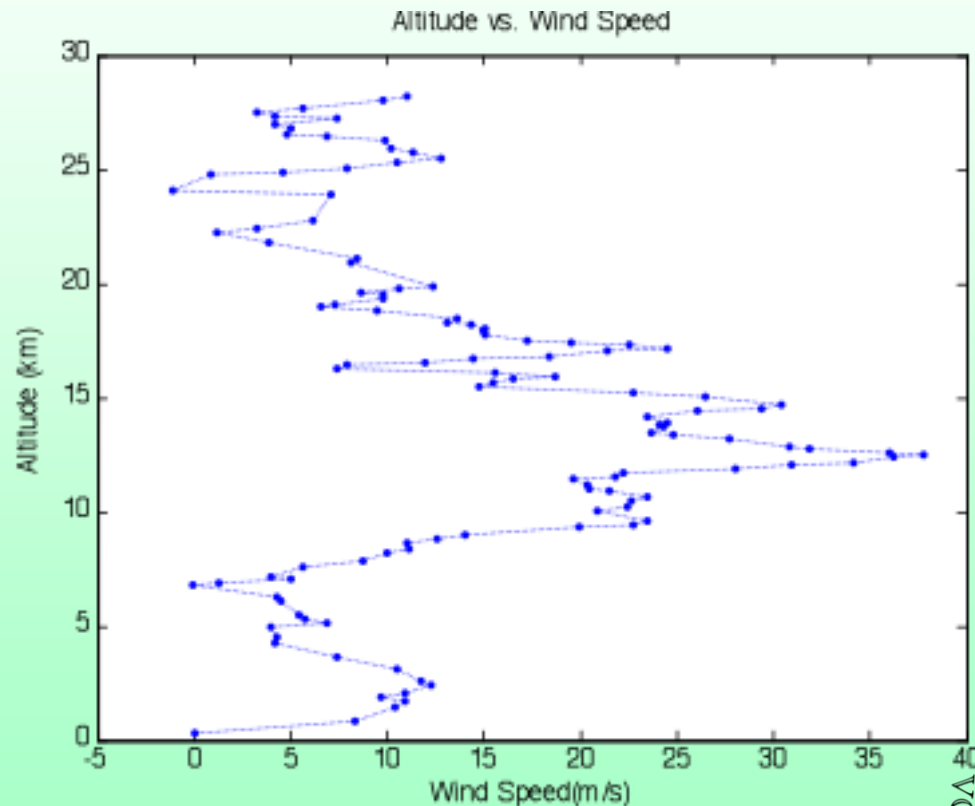
Ground Receivers

- Two stations
- Alinco DR-135T
- Argent Tracker2
- Laptop



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Flight 1

November 2008

Telemetry System & Flight Train

- Same as Flight 0
- Reporting at 30s data cadence

Instruments

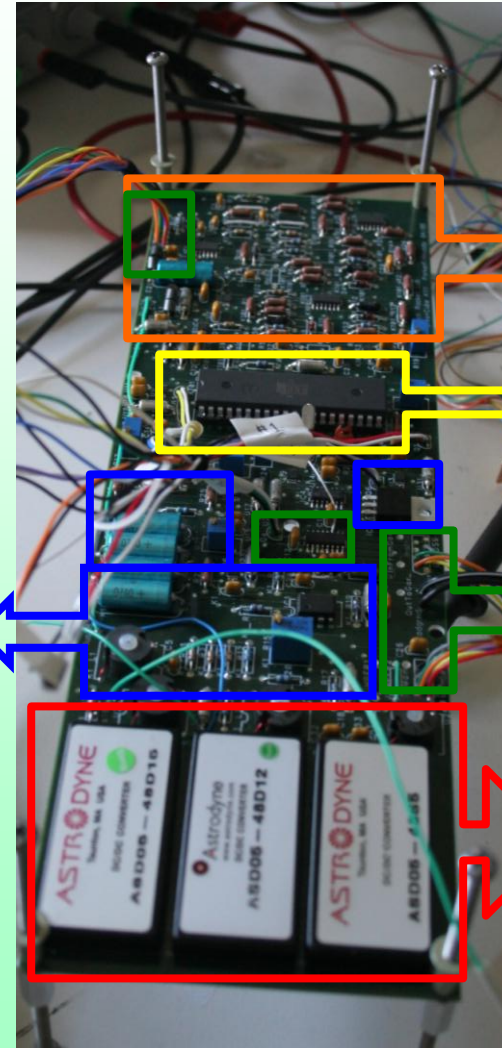
- Billingsley TFM100S Magnetometer
- LM135 temperature sensors
- Garmin GPS 15H

Control Board "K111"

- μ -Processor
- 16-bit ADCs
- Power DC/DC switching

CubeSat Summer Workshop August 2009

K111 Physical Layout



ADC

Microcontroller

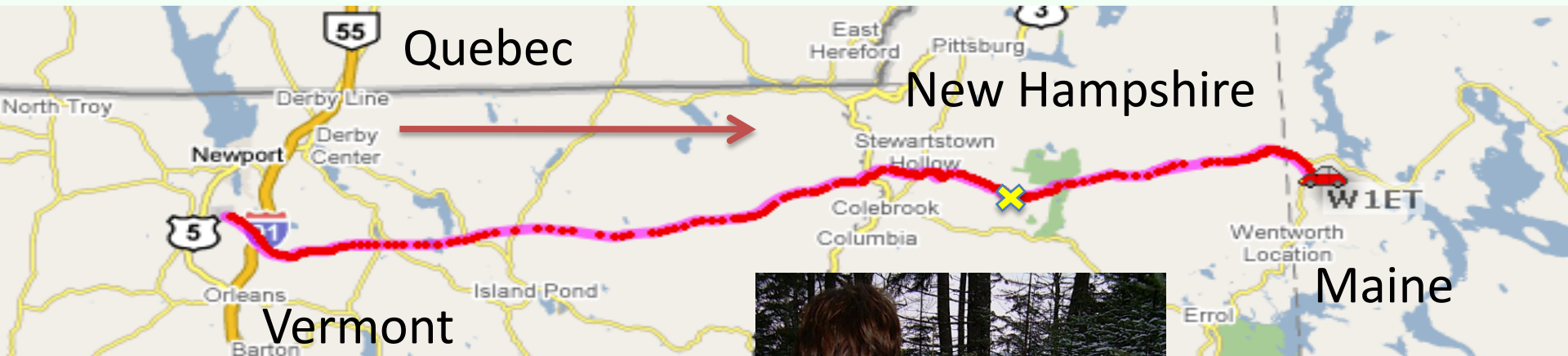
Power
Regulation &
Conditioning

Data I/O &
Power I/O

DC/DC



Flight Path

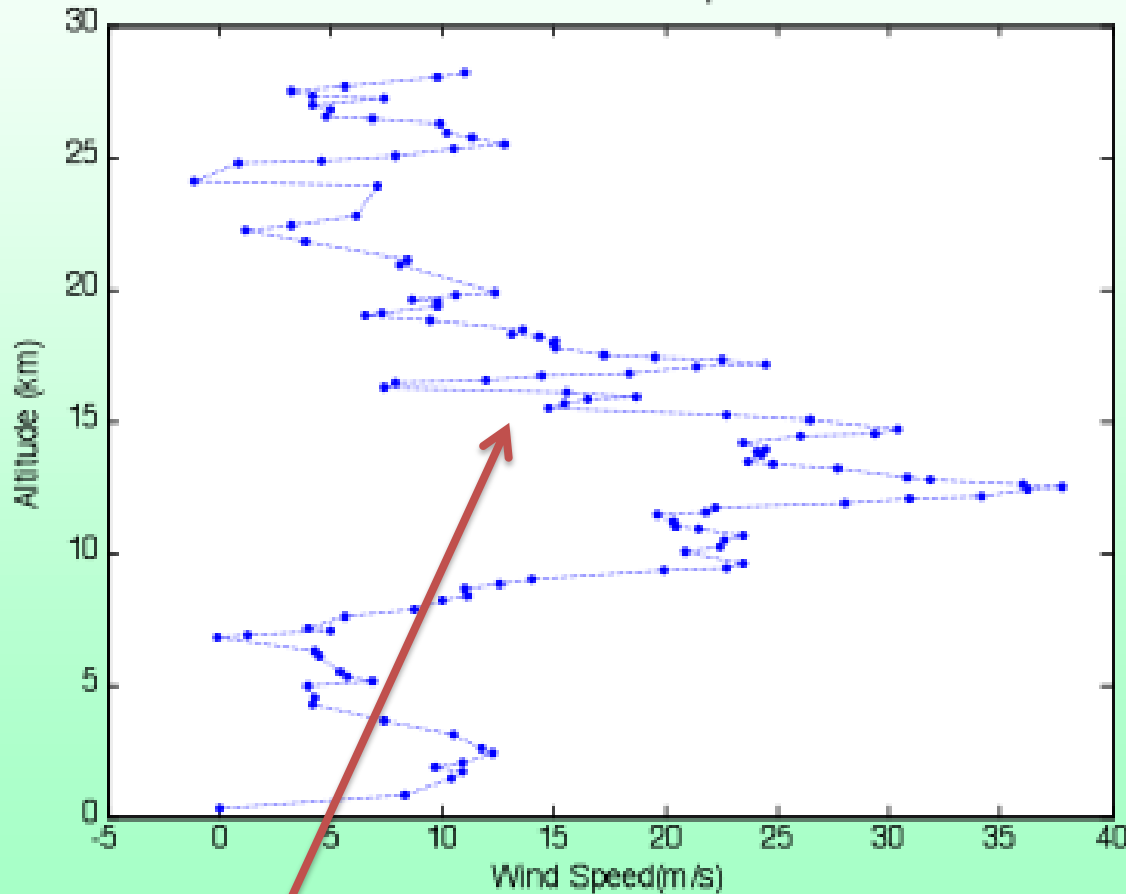


Telemetry Reported

- Lat., Long., Altitude
- 6 Internal temperatures
- 3 axis B-field
- Battery voltage

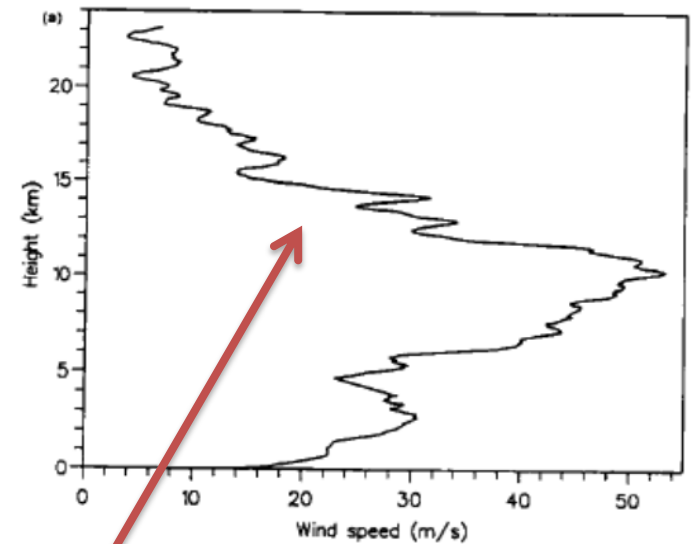
Data Collected

Altitude vs. Wind Speed



Flight 1 data derived from GPS telemetry

CubeSat Summer Workshop August 2009



Profile from a radiosonde
launched at 1335 GMT on
6 October 1989.

Shutts, G. J., P. Healey, S.
D. Mobbs. 1994



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GreenCube II: Flight 2

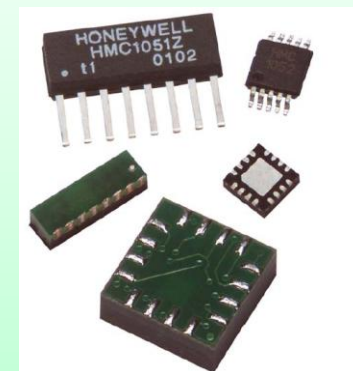
Purpose

Late August 2009 (?)

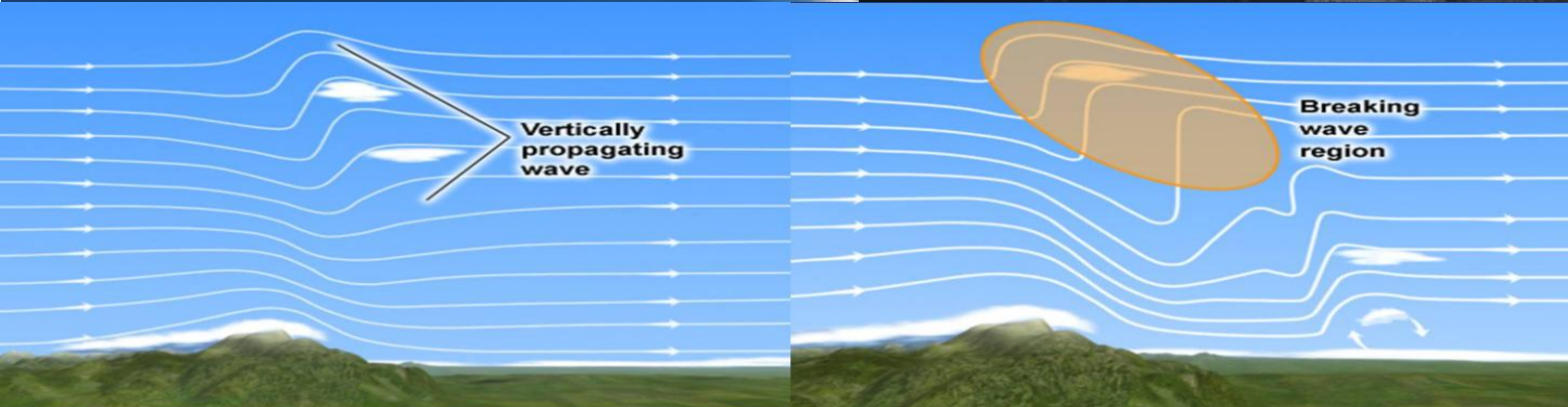
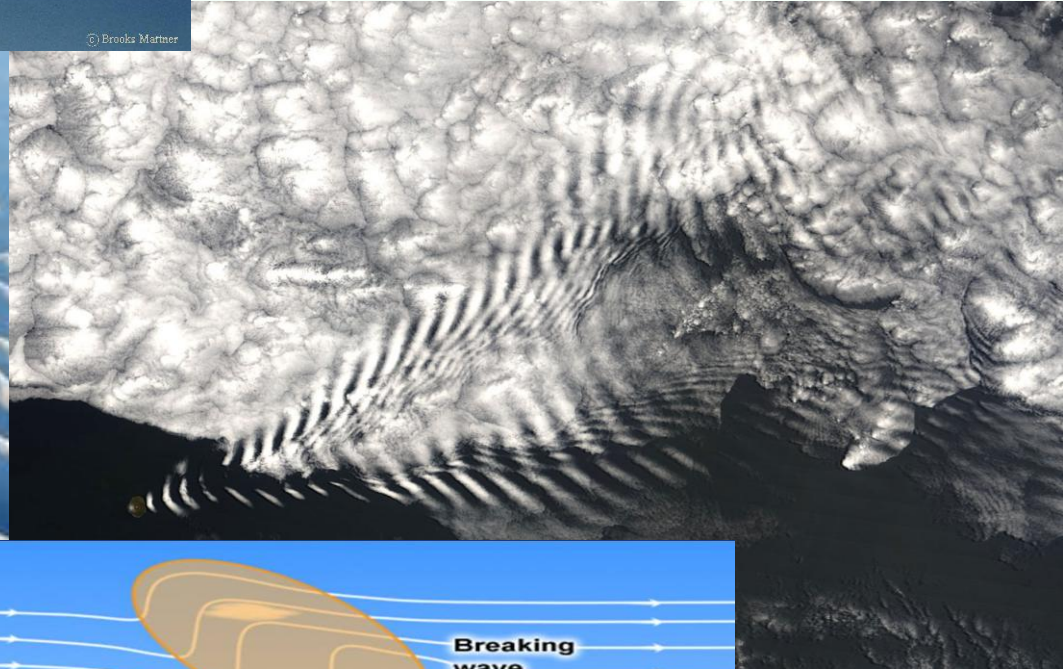
Detection of atmospheric gravity waves from the relative position and velocity of two balloons and the ambient gas temperature profile.

Differences from Flight 1

- Two Balloon Launch
- Higher Data Rate
- New Magnetometer: 3-axis Honeywell HMC 105
- Thermistors (PS-series) replace temperature sensors



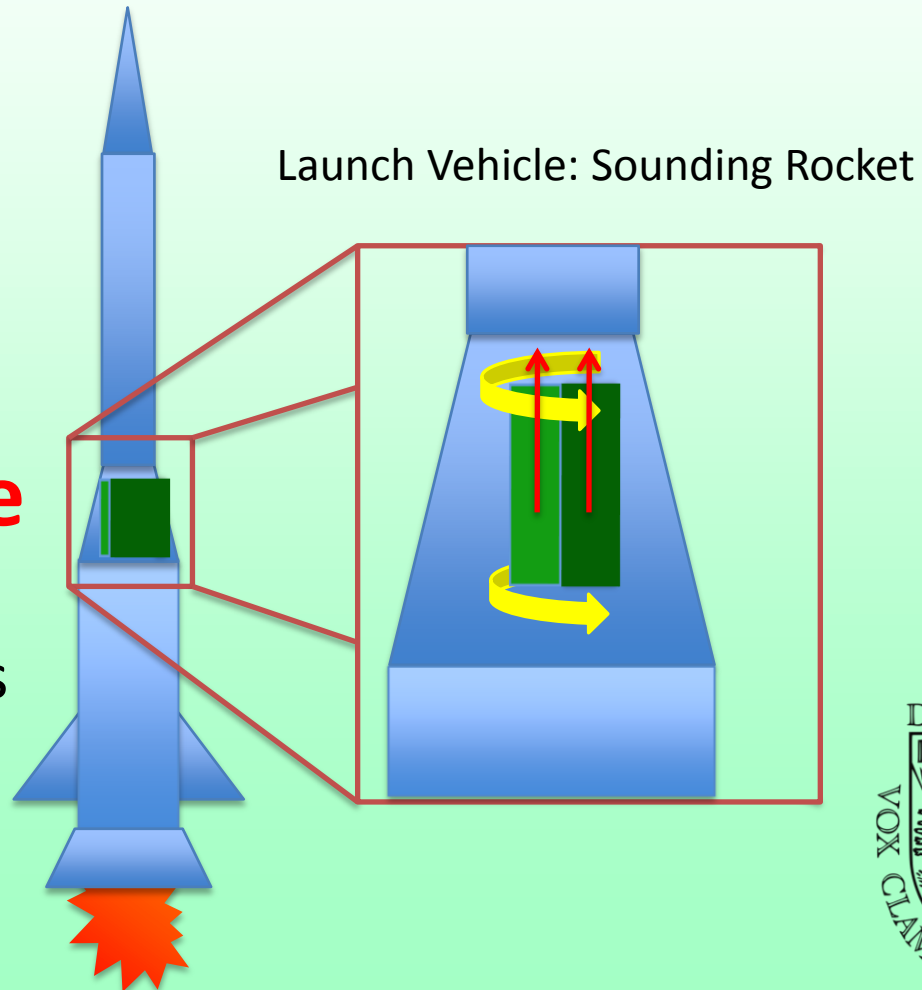
Gravity Waves



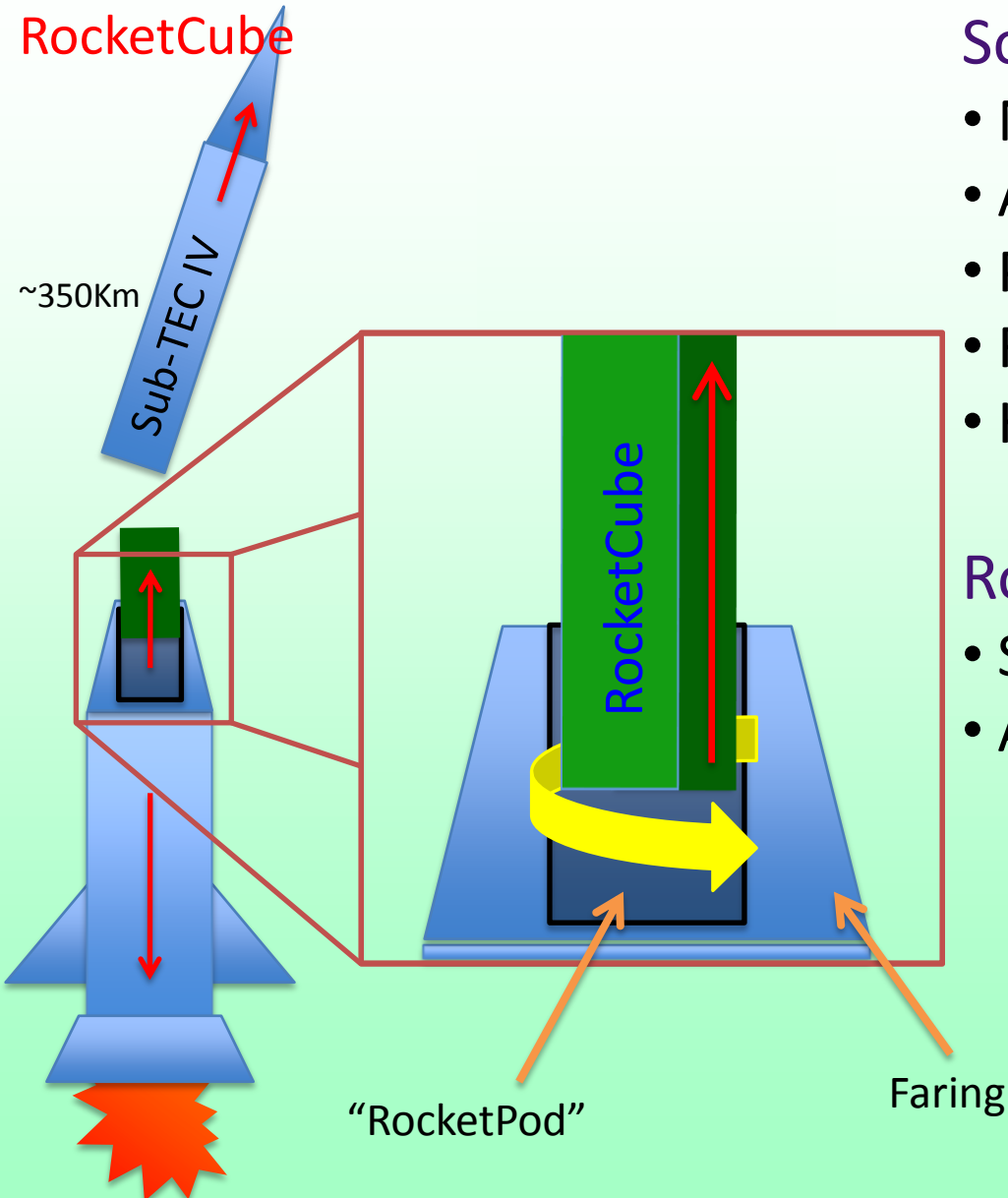
Courtesy (CCW): www.weathervortex.com/sky-ribbons.htm,
http://climate.snu.ac.kr/gcmdocu/Phy/Grav/3_Phys_Grav_Intro.htm,
http://earthobservatory.nasa.gov/images/imagerecords/6000/6151/amsterdam_tmo_2005353_lrg.jpg, www-frd.fsl.noaa.gov/mab/scatcat/

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Lynch Rocket Lab



Sounding Rocket Mission

- Name: Sub-TEC IV
- Achieve ~350km Altitude
- Plasma Environment
- Rocket Certified GPS
- High data rate telemetry (S-Band)

RocketCube Properties

- Spin stable
- Axial deployment



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RocketCube: Purpose

A Sub-Orbital CubeSat

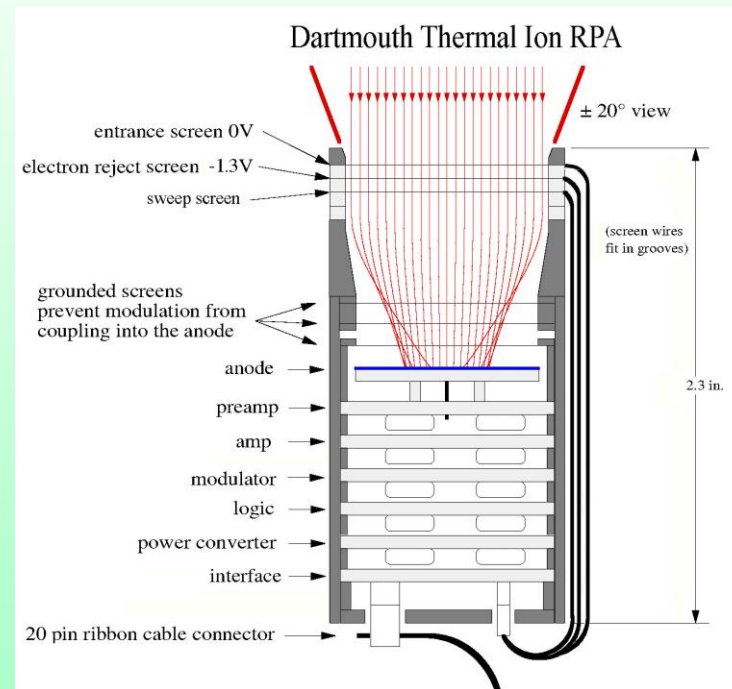
RocketCube is a technology development project which is a collaboration from three distinct groups

- **Lynch Rocket Lab**
 - Continued in-house development of very small sub-payloads for sounding rocket based auroral research
 - Test of a new thermal ion detector
- **NASA Wallops Flight Facility**
 - Demonstration of sub-orbital CubeSat deployment capability
 - Mesquito Mesospheric Sounder systems test flight (NSROC)
- **CalPoly CubeSat Program**
 - Cooperative development of a Sounding Rocket appropriate “PPod”
 - Methodology and heritage of integrating and launching sub-orbital CubeSats
 - Standard and Quality control



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Partnership & Components Map

Outside
Components

In House

CalPoly: Sub-Orbital
Deployer "TestPod"

Launch Vehicle
(Sub-TECIV)

Mesospheric Sounder
Mesquito
(Wallops & NSROC)

CubeSat
Standards
(CalPoly)

Mesospheric Dust
Detector

Thermal Ion
RPA Detector

RocketCube
A sub-orbital
CubeSat

GreenCube I
3U Balloon CubeSat 2008

GreenCube II 3U Balloon
CubeSat 2009
(Gravity Wave Probe)

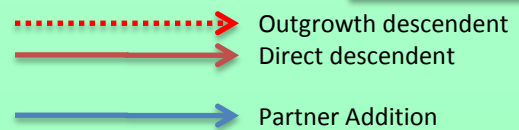
Lynch Rocket Lab In-House
In Development

Lynch Rocket Lab In-House
Developed

Lynch Rocket Lab In-House
Future Development

Partner Components

Auroral Sounding
Rocket Science
Proposal 2010



Component Specifics

• Dartmouth Components

- Mechanical structure 3U cube
- Electronics: payload control, housekeeping, and data acquisition board “K121”
- Power Distribution System
- Thermal Ion RPA detector
- Magnetometer

• NSROC Mesquito Components

- PCM Stack
- Microwave Innovations 2W S-Band transmitter
- Dual Band S and GPS wrap-around Antenna

- Javad OEM GPS

• Wallops Components

- Test Flight Rocket: Sub-TEC IV

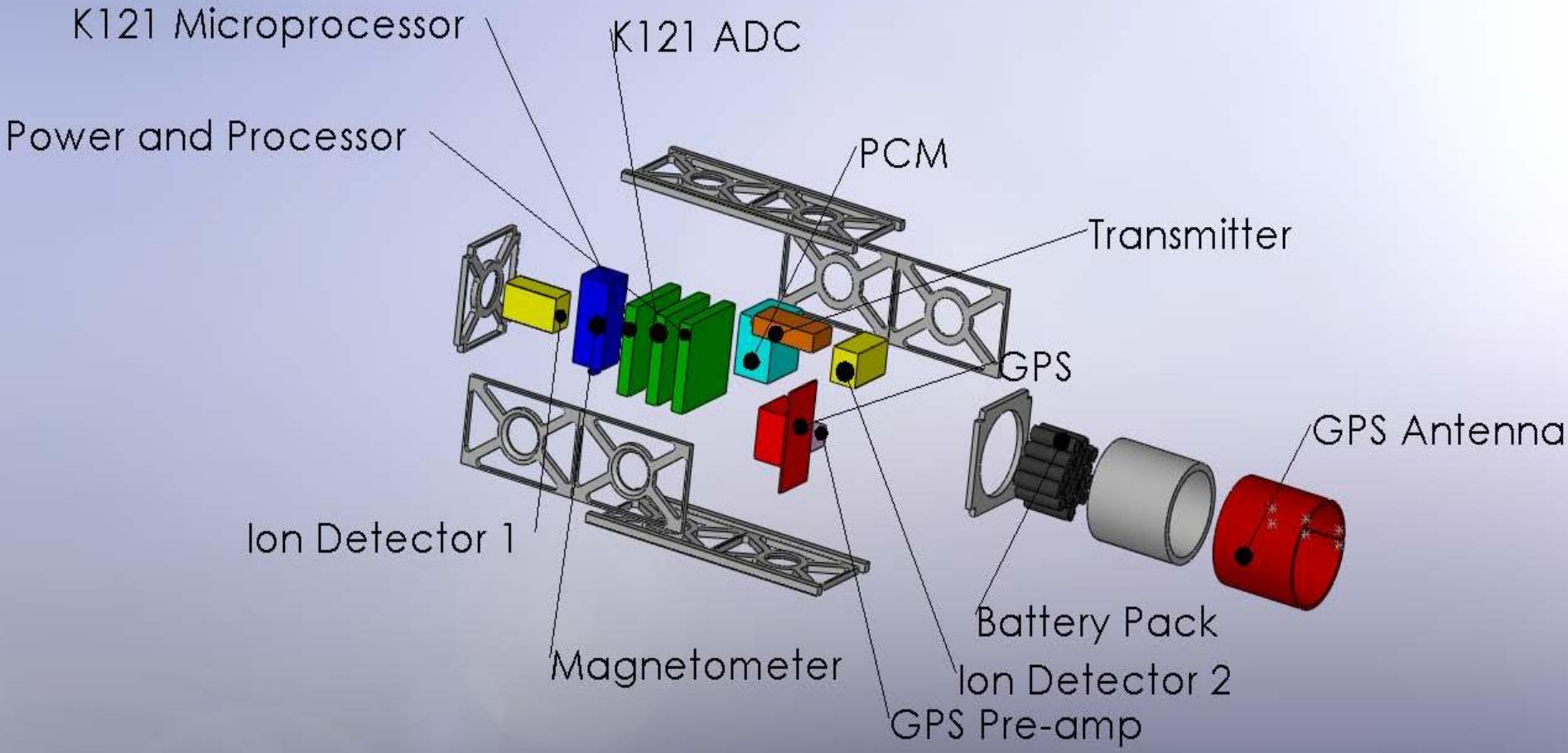
• CalPoly

- Sub-Orbital CubeSat Deployer based on existing “TestPod” design
- Quality Control

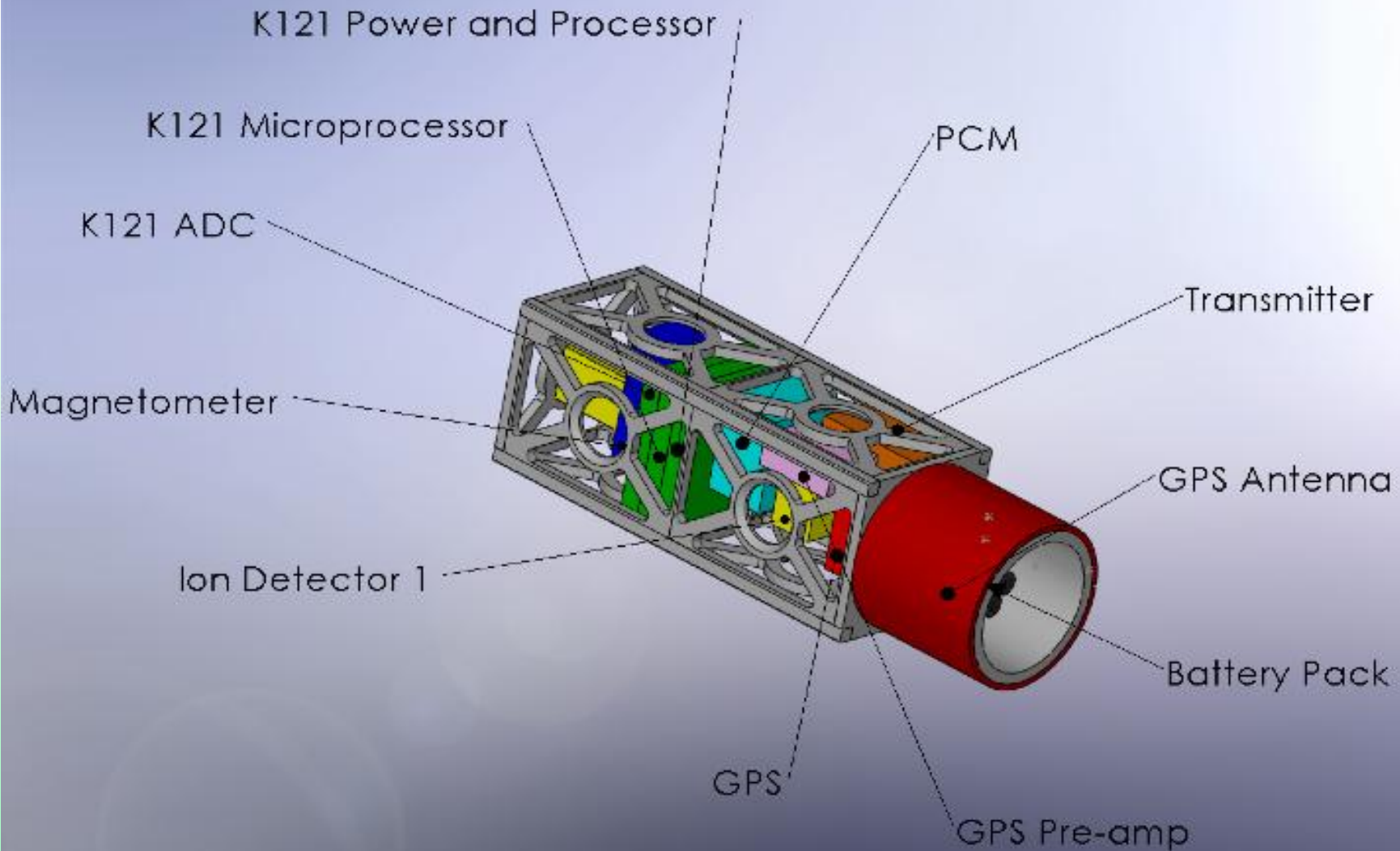
CAL POLY



Lynch Rocket Lab

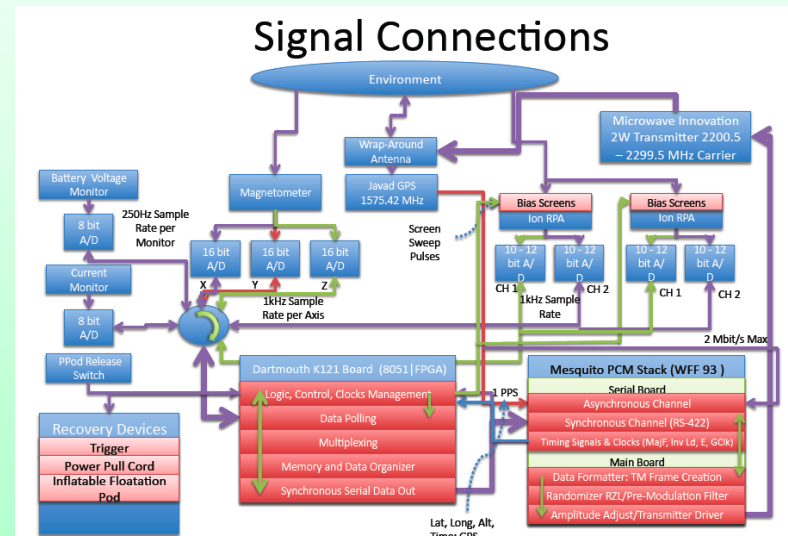


Lynch Rocket Lab



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Systems

Control Board “K121”

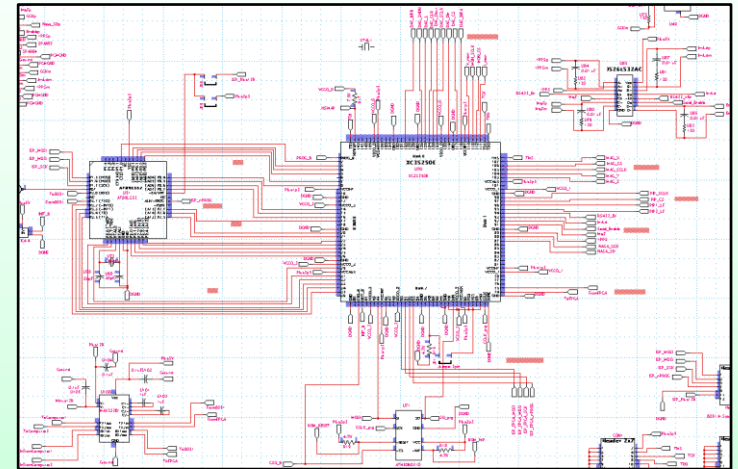
- Xilinx FPGA
- Atmel μ -Processor
- Interfacing

Analog Board

- 4 DACs for IRPA sweep and rejection voltages
- 16 bit ADCs
- Mag Filtering

Power Board

- DC/DC
- Linear regulators for clean and reference voltages



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Future: To Do List

Fabrication Fall 2009

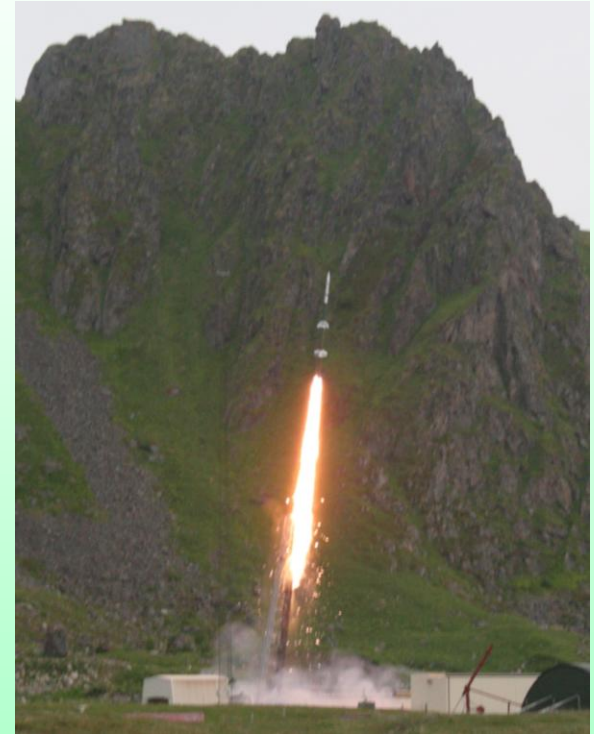
- Mechanical Drawings
- PCB Layout
- Systems Integration

Mission Initiation Conference (MIC)

- Define and set schedule for Sub-TEC IV test sounding rocket flight

Define and Build “RocketPod”

- Based on an existing CalPoly “TestPod”



Questions?

Contacts:

RocketCube @ Dartmouth.edu

GreenCube @ Dartmouth.edu

Phillip.J.Bracikowski @ Dartmouth.edu

<http://www.dartmouth.edu/~aurora/greencube.html>



Thank You!

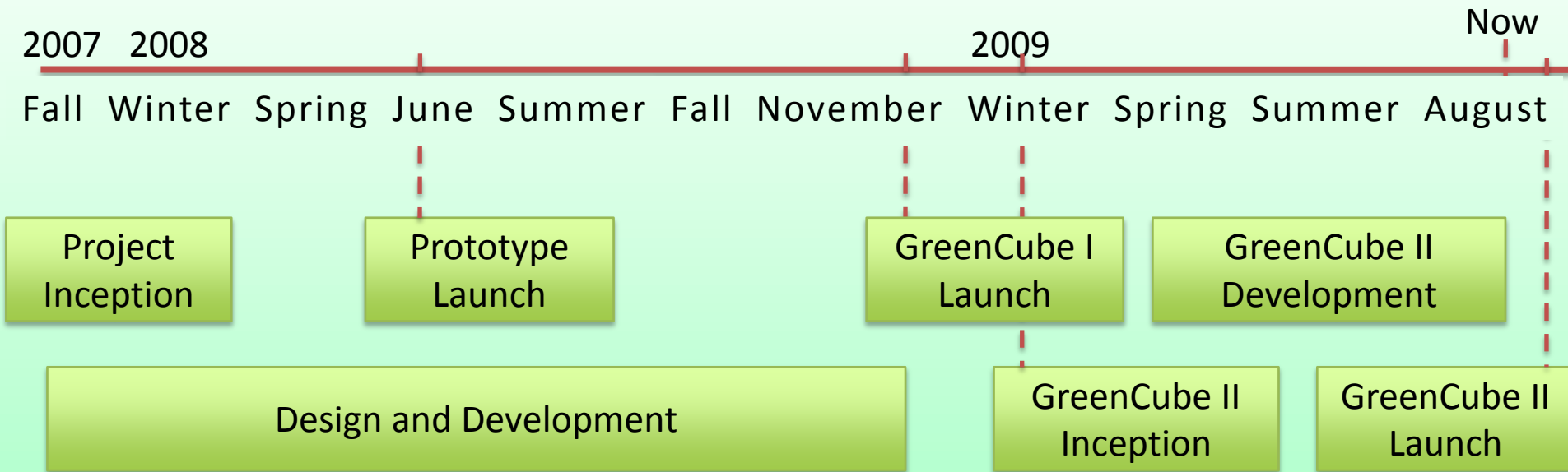


Lynch Rocket Lab



GreenCube

Timeline



RocketCube

Timeline

