Development of High-Altitude Technologies

University of Maryland Balloon Payload Project

Last edited: March 11, 2016

Overview

- Introduction
- Supersonic
- Balloon Attitude Determination And Stabilization System
- Bach’s Box
- Tracking System

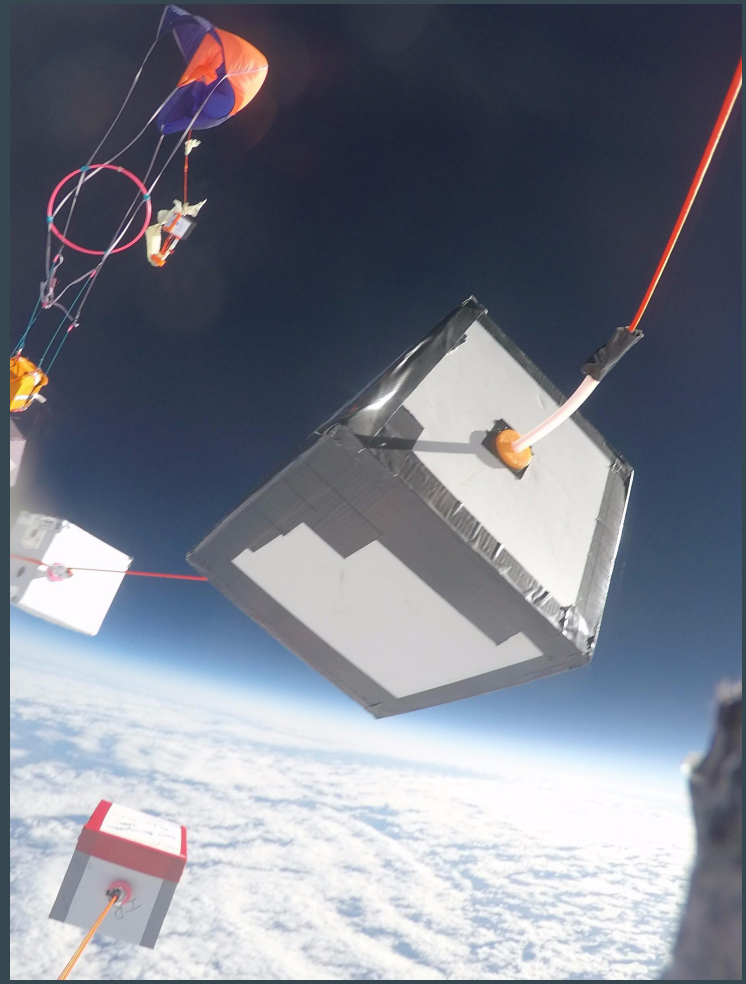


Photo courtesy of Bach’s Box

Balloon Payload Program (BPP)

- Started at UMD in 2003
- Funded through the MD Space grant Consortium
- Mostly undergraduates
- Freshman: Recruit and keep students interested in aerospace engineering
- Upperclassmen: Design and build meaningful flight experiments
- Educational outreach:
    - Maryland Day (April 30th)
    - NS-50: public launches

Fall 2015

Typical Launch Conditions

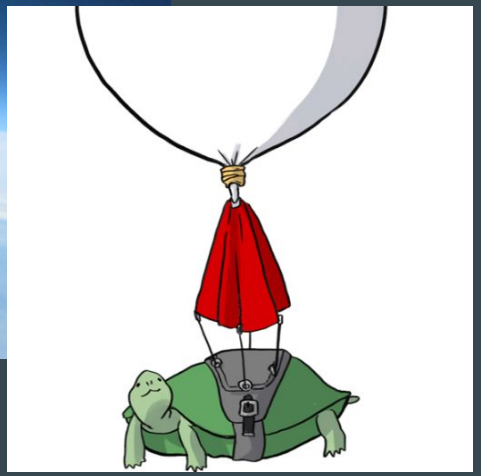
- Two launches in April which typically start at 4:30 AM
  - Balloon release, tracking, and recovery/debrief
- Extreme conditions during flight: -55 ºC min temperature, 1kPa min pressure, 70m/s max air velocity
- Payloads must be lightweight and follow federal and University regulations
- 20m nylon payload string with parachute and a tracking module

Rule of Ballooning: If there is a wide open field, the payloads will fall on top of the tallest tree.

Photos

Top: TurtleNest

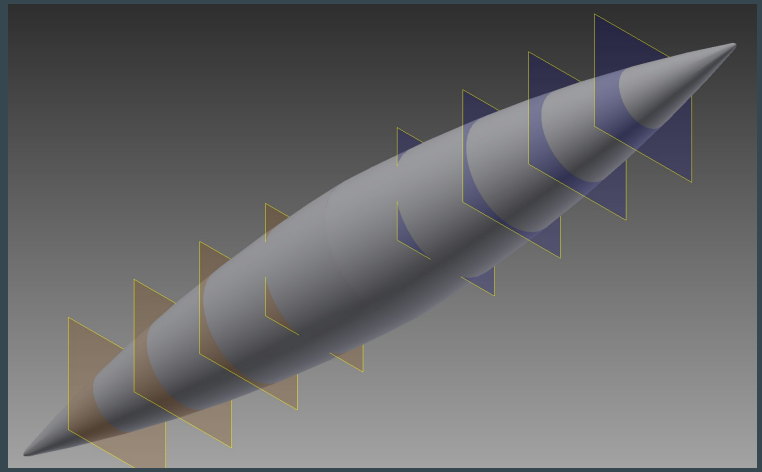
Right: Bach's Box



Chesapeake Bay from TurtleNest

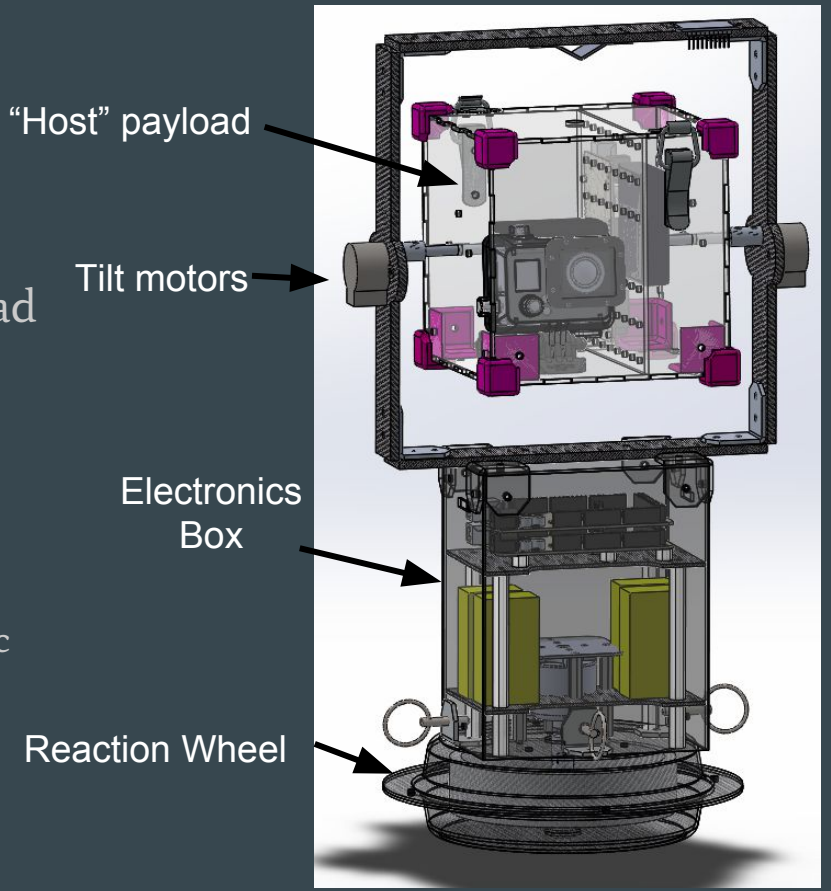
Supersonic

- Designed to drop from ~75,000ft and reach Mach 1 during descent
- Many complex subsystems
  - Requires high reliability
  - Redundant tracking, parachute, and control systems
- Fiberglass exterior aerodynamic shell
- 3d printed internal structure



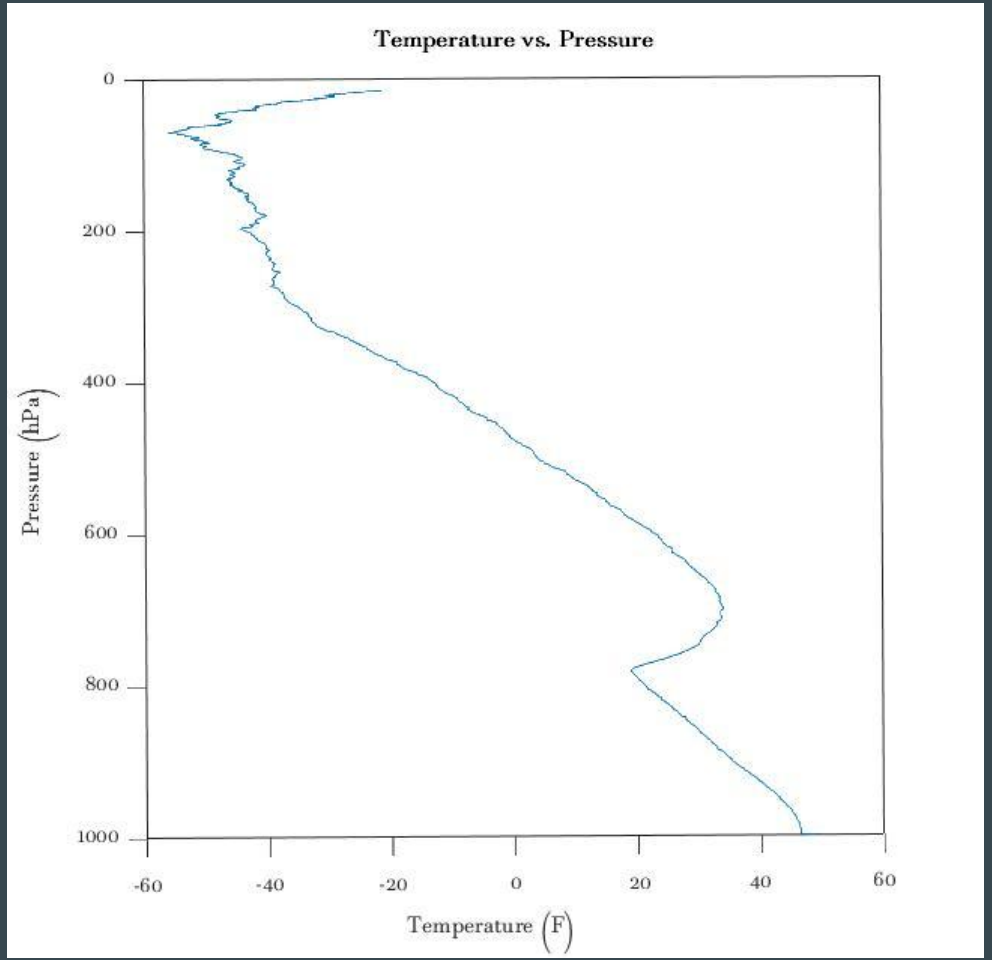
Balloon Attitude Determination And Stabilization System

- 2-axis payload stabilization system
  - Uses servo motors for tilt stabilization
  - Horizontal reaction wheel for attitude stabilization
- Can stabilize an arbitrary CubeSat-sized payload
- Custom carbon fiber structure
- Entire payload+host weighs only 4.5lbs
- First payload controlled by our new payload electronics platform: Balloonduino
  - Arduino Mega compatible board with payload-specific additions
  - Reduces cost and “boilerplate” work for payloads



Bach's Box

- Version 1
  - Could accurately measure temperature and pressure.
  - Was very reliable but had difficulty with relative humidity.



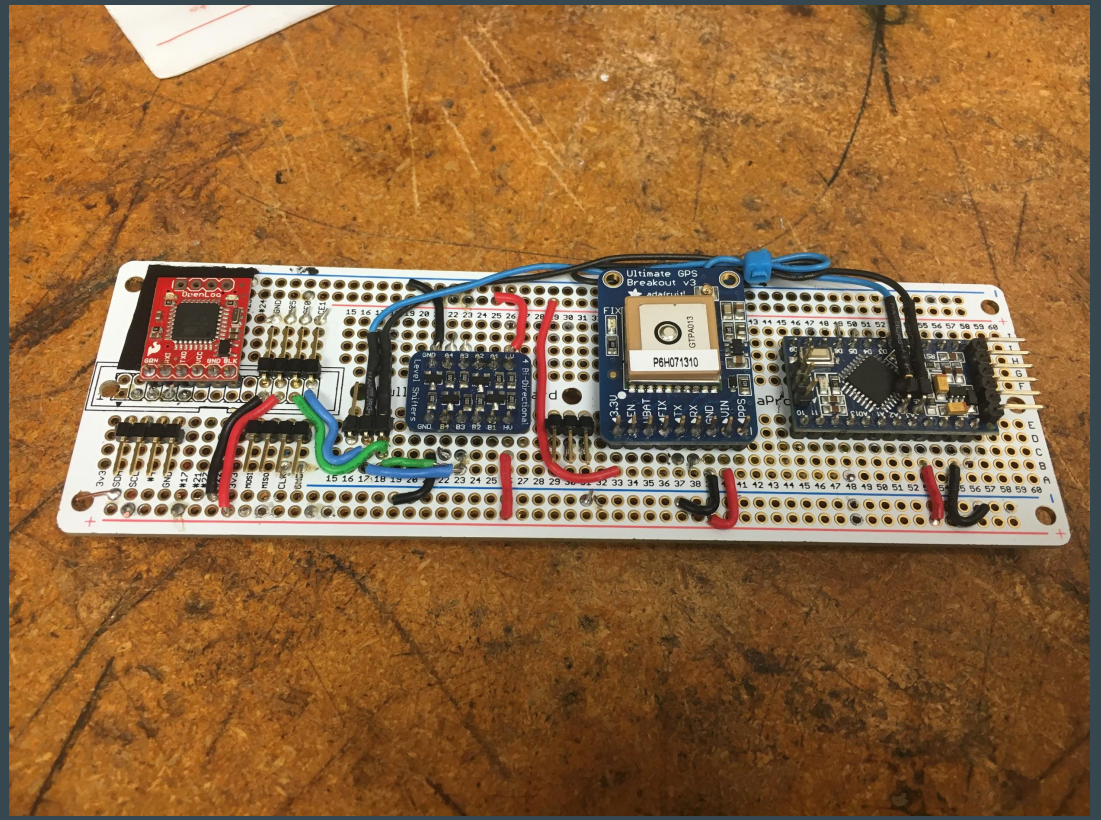
Bach's Box

Specifications of Version 1 and a Vaisala RS-92D sonde

			DS18B20		RHT03		BMP085		Vaisala RS-92D
Temperature	Operating Temperature		-55°C to +125°C		-40~80° C		-40 to 85°C		-90 to 60°C
	Accuracy		±0.5°C		±0.5°C		±2°C		±0.5°C
Humidity	Humidity range				0 to 100%				0 to 100%
	Accuracy				±2%				±5%
Pressure	Pressure range						300 to 1100 hPa		100 to 1080 hPa
	Accuracy						0.03 hPa		1 hPa
	Pressure range								1 to 100hPa
	Accuracy								.6 hPa

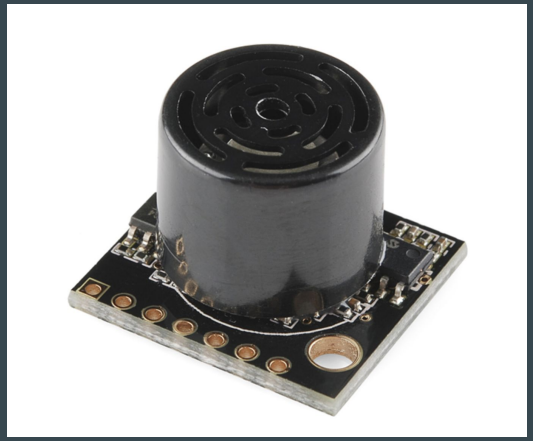
Bach's Box

- Version 4
  - GPS tracking.
  - Multiple temperature and pressure sensors.
  - Weatherproof humidity sensor.



Bach's Box

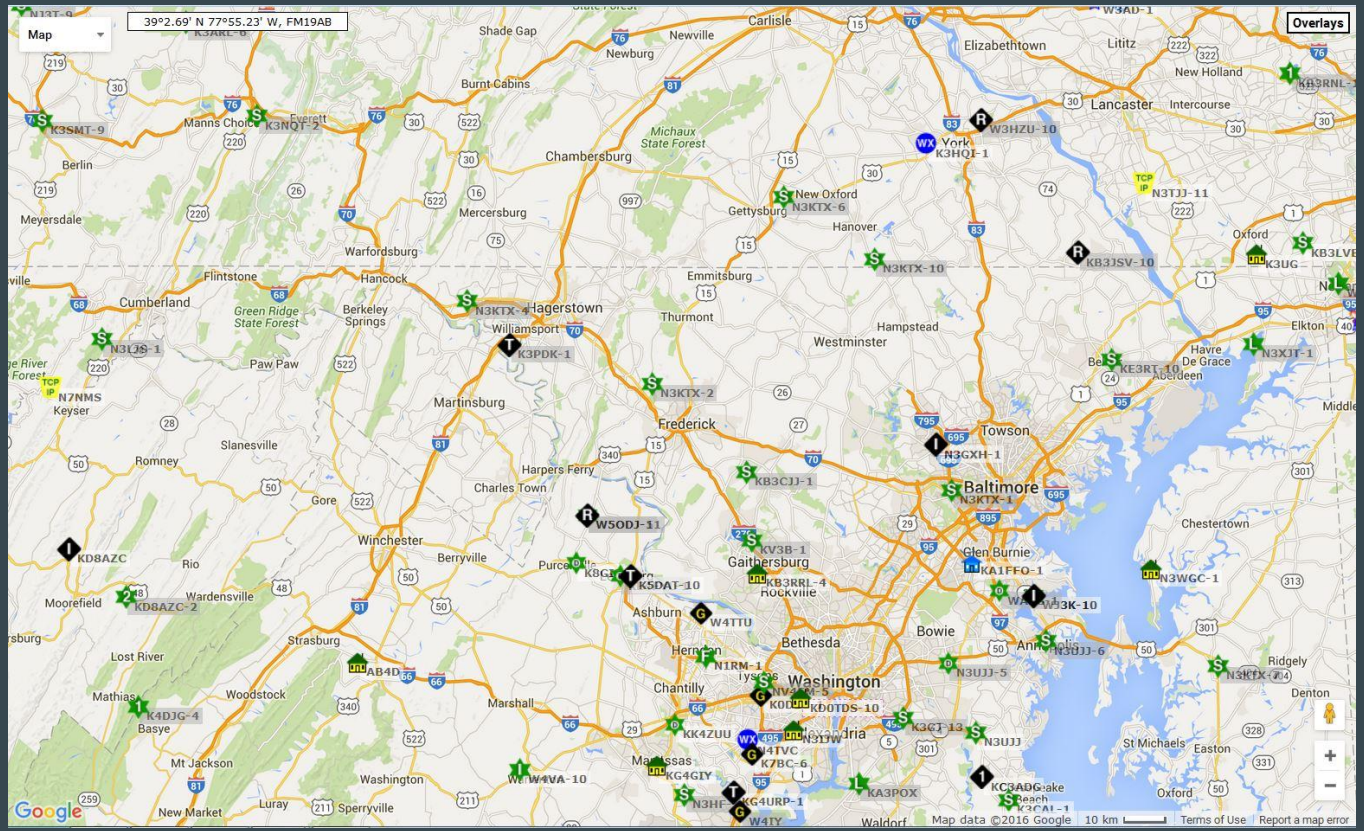
- Experimental Unit (Version 3)
  - Multiple units - it communicates by an i2c bus.
  - LIDAR - tells distance away from objects up to 40m.
  - Sonar - resolution of objects as small as 1mm.
  - Ozone - our high altitude launch into the stratosphere.



Tracking

- Tracking required over full flight envelope of balloon
  - 100k+ feet altitude
  - 30+ miles horizontal distance from base (worst case)
  - Non-line-of-sight mode below 1000 feet AGL altitude
- Primary tracking is two redundant 2m-band (144.39 MHz) radios over APRS
  - Packetized, unidirectional (air to ground)
  - Operates on ametuer (HAM) frequencies - we have many licensed operators!
  - Packets pushed to internet via ground stations
- Secondary tracking over cellular phone network (low altitude)
- All electronics run on Arduino platform
- Ground functions coordinated from lead chase van

Tracking - APRS Ground Stations



From aprs.fi

Tracking - Next Steps

- Live bi-directional communication
  - APRS is sparse and one-way
  - Bi-directional necessary for some in-development payloads
  - Continuous, real-time telemetry could open up new avenues of design
- Custom telemetry software
  - Helpful in enabling bi-directional communication
  - Allows better visibility into tracking data
  - Could drive steerable antenna - better reception

Tracking - Pictures

Typical Launch Schedule

NS -51 Pizza Debrief

Friday afternoon

- Pick up vans
- Final ground track & weather predictions
- Launch decision: Sat or Sun
- Flight readiness review of all payloads

Saturday morning

- 430am - meet at SSL and load vans for 5am departure
- 7am - gather in Clear Spring, MD, for payload string assembly
- 8am - balloon inflation & final payload closeout
- 830am - balloon release then all tracking vehicles load up and chase
- 10am - payloads land somewhere (MD, PA, WVa, VA)
- 11am - payloads tracked and found, usually in the top of tallest tree
- 1pm – eat lunch at Pizza place and debrief

Contributions of BPP

- Opportunities for paid undergraduate engineering experience
- This program has gotten our name out there.
  - CanSat Win, NFB Coverage, Altitude Record, CO Workshops
- Outreach to Comm Colleges, and High Schools
- Faculty at other schools rely on our launch capability
  - UMCP, UMBC, UMES
  - Morgan State University, Hagerstown Community College
  - Capitol Technology University, Carver Center High School
- Increased enthusiasm for and understanding of engineering
- Past Balloon Program leaders now working at JPL and SpaceX

Thank you!
Any questions?

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