

Sending a Balloon to the Edge of Space

*Luke Bowsher, John Kim, Vivian Liu, Simon Oros, Caroline Pang, Alec
Vercruysse*

November 13, 2018

Abstract

This paper details 6thsense, a mission to send a weather balloon to the edge of space in order to study Earth's atmosphere. The weather balloon is outfitted with a payload that includes a camera, inside and outside temperature sensors, a barometer, multiple GPS tracking devices, as well as a host of individual experiments. The balloon most likely reached an altitude of 20,000 meters, into the stratosphere and ozone layer. The balloon was successfully recovered after approximately one and one half hours of flight.

Contents

1	Introduction	4
1.1	Background	4
1.2	Greenhouse Gases in the Atmosphere	4
1.3	Empirical and Exponential Models for Temperature and Pressure	8
2	Experiments Conducted	9
2.1	Group Experiments	9
2.1.1	How a Pressure Sensor Works	10
2.2	Individual Experiments Conducted	10
2.2.1	Alec Vercruysse: Spectrometer	10
2.2.2	John Kim: Methane Sensor	11
2.2.3	Caroline Pang: UVB Sensor	11
2.2.4	Vivian Liu: Light Intensity and Solar Power	12
2.2.5	Luke Bowsher: Accelerometer	12
3	Physical Design	12
3.1	Payload Design	12
3.1.1	Structure	12
3.1.2	Organization of Parts	13
3.2	The Tethered Launch Reel-in System	14
3.2.1	Structure	14
3.2.2	Gears and Axle	14
3.2.3	The Tensioning System	15
3.3	Fox-Hunting Yagi Antenna	15
3.4	Calculating Payload Weight	15
3.4.1	Buoyancy Force Calculations	15
3.4.2	Buoyancy Force at Highest Altitude	16
3.4.3	Derivation of Exponential Model of Pressure	17
4	Cut Down Mechanism	18
4.1	Cutdown Method	18
4.2	Charge Needed	19
4.3	Capacitor Bank	19
4.4	Transistor Relay System	20
4.5	Circuit Walkthrough and Physical Design	20
4.6	Cutdown Testing	21
4.7	Final Code	21
5	Electrical and Software Design	22
5.1	Background	22
5.2	Electrical Design	23
5.3	Software Design	24

6	Tracking the Payload	25
6.1	The Global Positioning System	25
6.2	The PicoAPRS Transceiver	26
6.3	The APRS Network and MIC-Encoding	27
6.4	The 900MHz Venus GPS Transciever	28
6.4.1	A Novel Transmission Protocol	28
6.4.2	Physical Considerations and Antenna Design	29
6.5	Fox-Hunting with a 147.065MHz Transmitter	30
6.5.1	Fox-Hunting Yagi Antenna Design	30
6.5.2	Determining Signal Strength with a Variable RF Attenuator	30
6.6	Results	31
6.6.1	The Venus GPS and 9XTend Module	31
6.6.2	The PicoAPRS and APRS Network	32
6.6.3	The Fox-Hunt Beacon and Yagi Antenna	32
7	Sensor Calibration	33
7.1	Pressure	33
7.2	Humidity	35
7.3	Temperature	36
7.4	Error Bars	38
8	Experimental Results	41
8.1	Descent	42
8.2	Evaluating NASA's Temperature Model	43
8.3	Modeled vs Actual Trajectory	45
9	Conclusion	45
10	Acknowledgements	46