

Project Title:

Design and Launch of a Balloon Re-entry Vehicle for Free Fall Experimentation

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1.0 Abstract

The Wright State University High Altitude Balloon (WSU HIBAL) project is working on developing a redesign of a more reliable launchable system for the high altitude balloons. The previous teams have had challenges in terms of flight and launch capabilities. The capsule shape (where all the electronics of the project is stored) redesign will be the goal. A shape improvement of the capsule and release mechanism is needed. To overcome the roadblocks while launching, a fabric tent-like enclosure was designed to shield the balloon from high ground wind speeds and other hazards during the filling process. Balloon filling procedures and payload connections will be individually tested and redesigned to reduce the risk of balloon loss during launches. The WSU HIBAL team will have an easier launch time under harsher conditions and greatly reduce complications for current and future teams.

2.0 Introduction

The concept of using an aerodynamic lift and drag to effect the change in orbital energy or plane is classified as aero assist. This was first introduced in 1960, as a technique for substantial cost savings. There is a variety of types of assists that exist including direct entry, entry from orbit, aerocapture, aerobraking, and aero-gravity assist. This project will only focus on aerocapture. Aerocapture will subject an orbiter of a deceleration of higher value and heating (both heat rate

and heat load) than aerobraking due to the large velocity reduction achieved in a single pass. The profile of the project is illustrated better in Figure 2.1.

The Rapid Eye system is a project developed by the Defense Advanced Research Project Agency. This project will allow the military to rapidly respond world-wide to developing situations and quickly provide decision makers with the persistent coverage of time-critical events. The project will provide the military with the necessary assets to monitor unexpected event and control the situation until other necessary tools are put into place.

The term ballute, a combination of the words “balloon” and “parachute” was first given to the project by the Goodyear Aerospace Corp for a balloon they invented in the shape of a cone. The term is famous in literature now, and is used as an analogy to any inflatable drag device for high speed deceleration. In Figure 2.2 this paper features some of the different ballutes divided into clamped and trailing types.

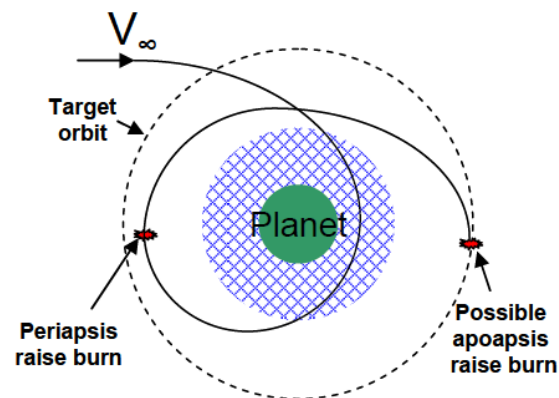
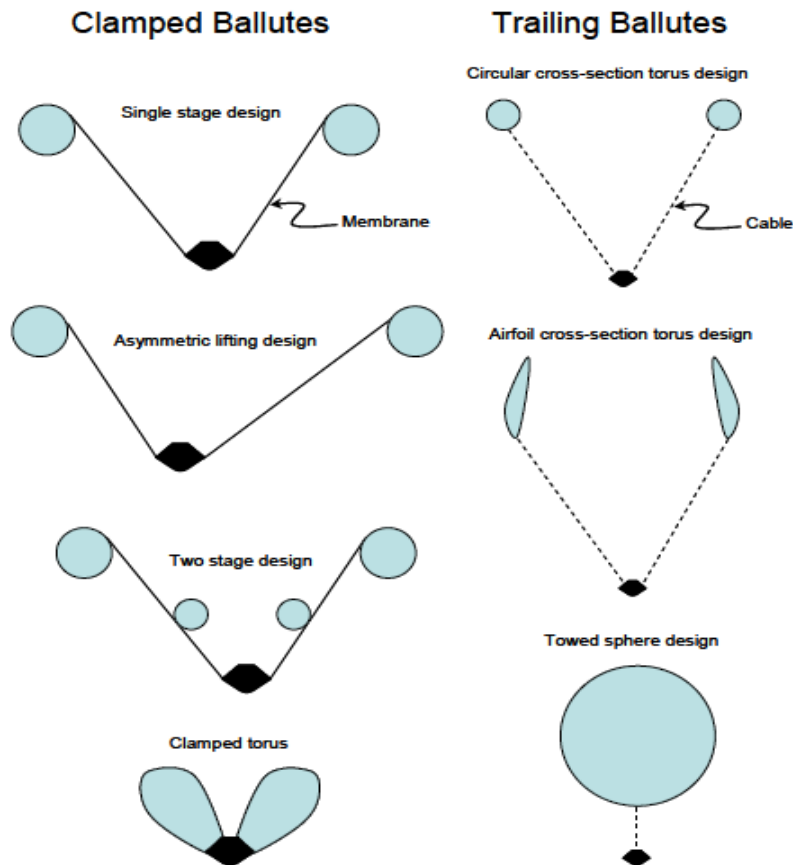


Figure 2.1, Aerocapture mission profile [1]

Figure 2.2. Examples of clamped and trailing ballutes [1].



In early 1982, the approach to a new design for the ballute was a very interesting idea because of the cost savings associated with it. The incorporation of the thin-film ballute technology increased the cost savings by double. Illustrated, in Figure 2.3, there is a histogram showing the percent mass and cost savings over the aerocapture option for planetary missions.

The instability of the drag coefficient was utilized in the early years of the project as a supersonic decelerator for Mars entry. The ballute used a Nomex or Dacron cloth. A target of 20,000 ft of altitude was achieved. In 1968, tests were also conducted with metal ballutes, showing no advantage over the thin-filmed ballutes. Recognizing the potential mass and operational advantages of a ballutes system over the years different designs of ballute systems were proposed.

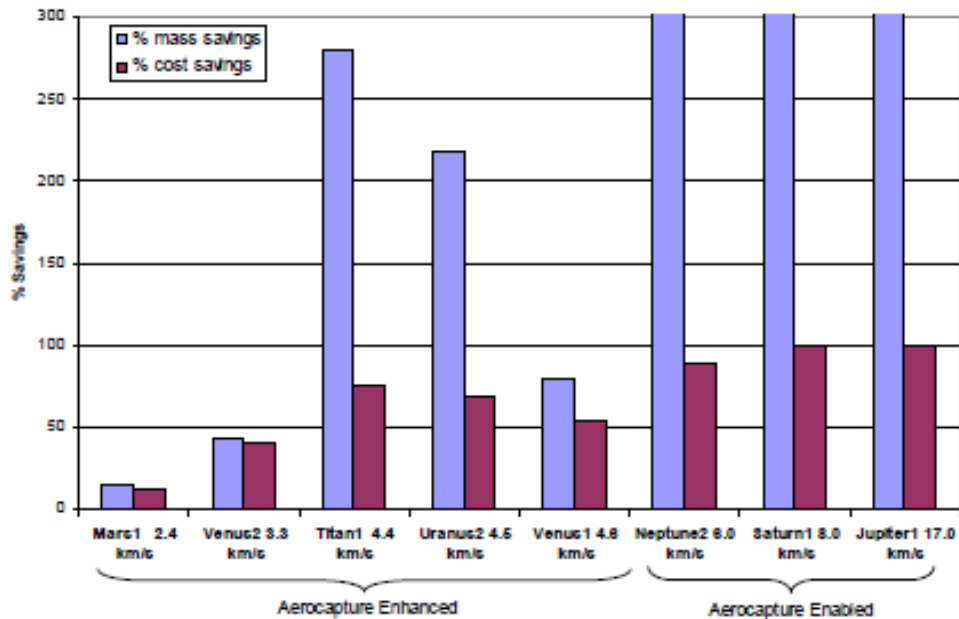


Figure 2.3. Percent mass and cost savings over a nonaerocapture option for planetary missions using rigid aeroshell aerocapture (1).

The Wright State University High Altitude Balloon Team is working on a ballute mechanism that is similar to the previous experimental projects. There will be a difference in the balloon deployment mechanism and the ballute is that they will already be filled with helium before it launches. In Figure 2.4, a schematic is shown of what the previous experiments had worked were thought to be.

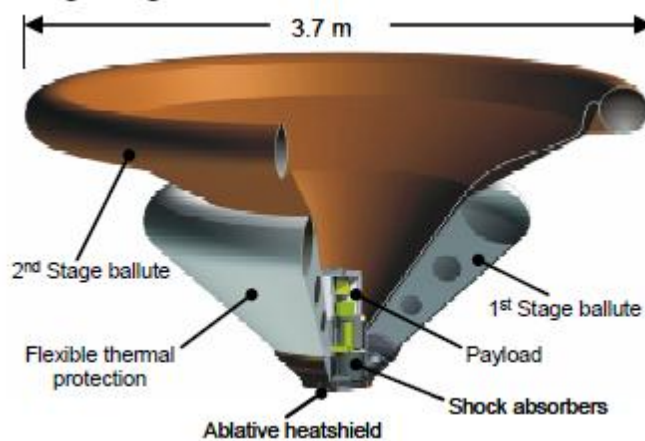


Figure 2.4: Ballute stage 2 deployment mechanism, 2003 (1).

3.0 Goals

The 2009-2010 WSU HIBAL Team will have two main goals to accomplish during our project year.

3.1 Goal 1. Design a “door” mechanism that will allow the parachute to deploy whenever the electrical circuits “tell it to”.

3.2 Goal 2. Test the ballute in free fall and collect data from the built-in accelerometers that will sustain the CFD analysis with the comparison data collected from our experimental study.

4.0 Design Criteria

In the study flow stability is one of the main concerns as in their research the system appeared to be highly unstable with ballute orientation changes in large scale. Figure 4.1 illustrates a flow stability analysis done.

Some of the team’s concerns are the harsher weather conditions that our system will be encountering once at an altitude of 100,000 ft. One of our main concerns is the temperature encountered at such altitudes which varies from (-50°C to -60°C). The team has to find materials that will withstand such low temperatures. Harsher conditions like storms, uncertainty in the wind or freezing will be the team’s more important areas of improvement. It is of great importance to solve the problems associated with the design of experiment for this project.

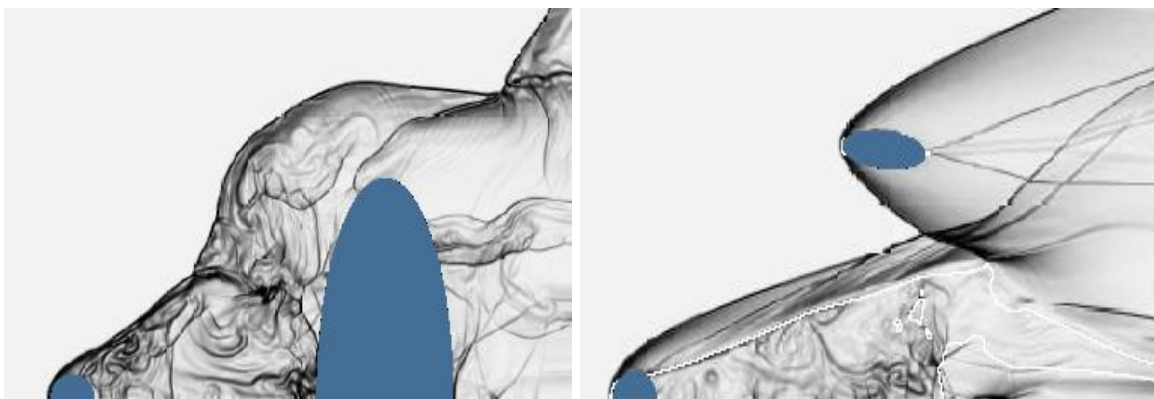


Figure 4.1: (left) flow analysis for toroidal shape mechanism.
(Right) Different view for steady flow analysis .

5.0 Technical Approach

Figuring out a “door” mechanism for the system is important as it is very closely connected to the parachute deployment mechanisms. For the “door” different types of materials were tested. In Figure 5.7, a similar idea with our team’s project is illustrated. This structure was studied and implemented in 2003 by *Braun and Rohrschneider*, to determine the aerocapture capability of ballutes in Titan. The difference will be in the parachute deployment mechanism for the WSU HIBAL TEAM and the built-in mechanisms. The team would like to have the balloon already filled with helium and ready to launch. The challenge that we face is having a new shaped balloon as Figure 5.8 illustrates. Until now the Team was proposed several different shapes for the balloon with various advantages. However, issues rely on the system’s mass and drag capabilities. The Team intends to study and collect data with the following toroidal shape. However, in the design that we are currently flying a teardrop shape as shown in the below configuration would be more likely to work for our project.

Figure 5.1 illustrates a configuration of what we have been flying and plan on flying on the future.

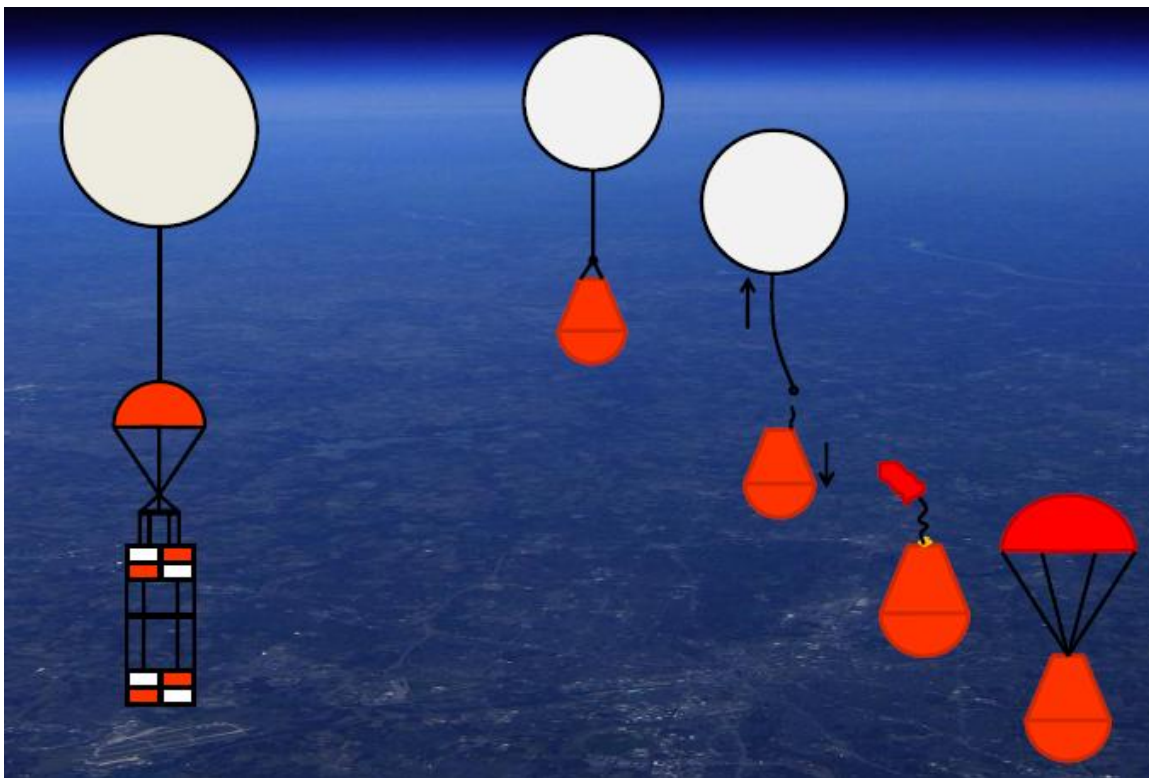


Figure 5.1: illustrates the configurations currently being flown

This configuration was flown in the past two launches allowing the team to be able to collect data through accelerometers. Figure 5.2 illustrates the strap down navigation system needed to collect.

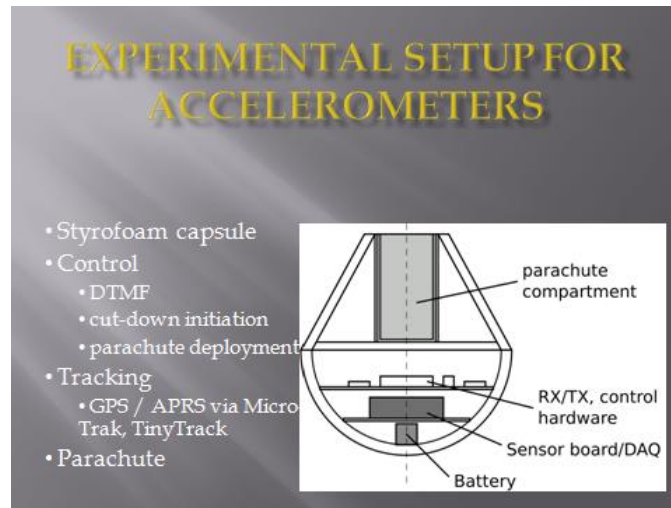


Figure 5.2 illustrating the configuration of the accelerometers in the teardrop

In order for the team to test this system and collect data it was first tried to collect fudge data just to understand how the gyro's and the accelerometers worked in a normal two box system. Figure 4.4 illustrates the configuration flown in mission 15, where a successful cut down through NiChrome wire was accomplished.

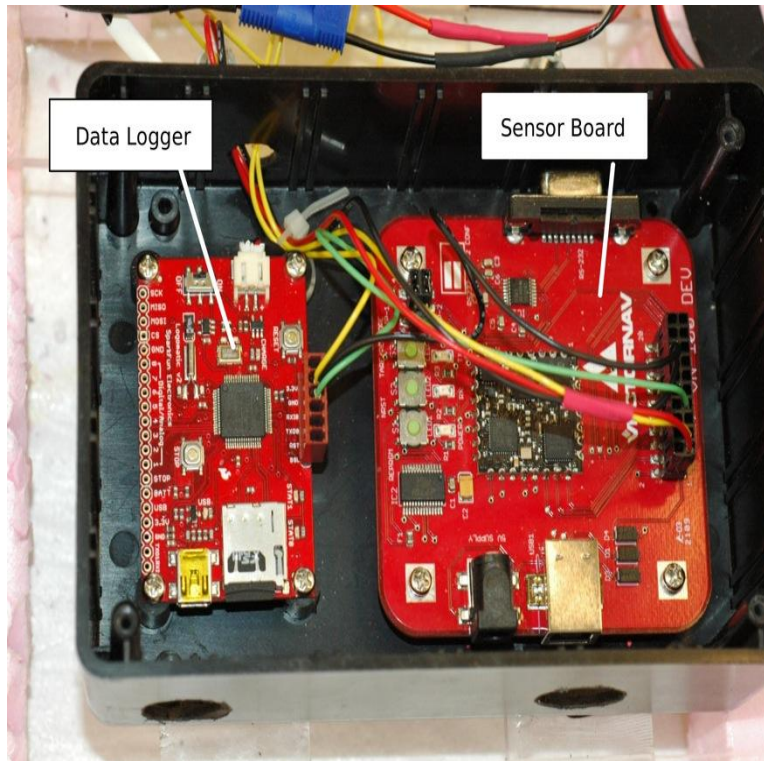


Figure 5.3 illustrating the configuration of the accelerometers in the box

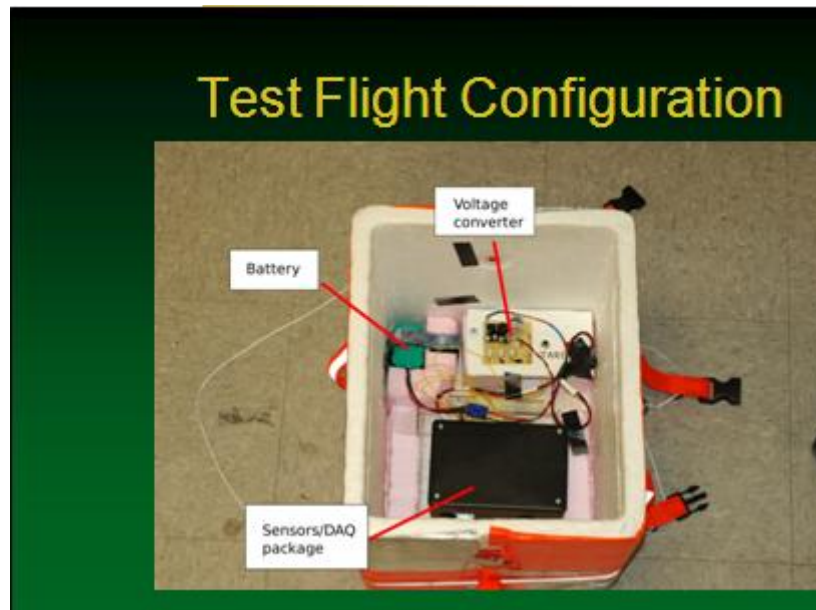


Figure 5.4 illustrating a better flight configuration flown

This configuration was flown under really good environmental conditions. The weather was around 15 degrees Celsius and sunshine. This helped the cut down and the collection of data very much. In figure

5.5 an illustration of the data collected will show the idea of the free fall data should look like for our future flights.

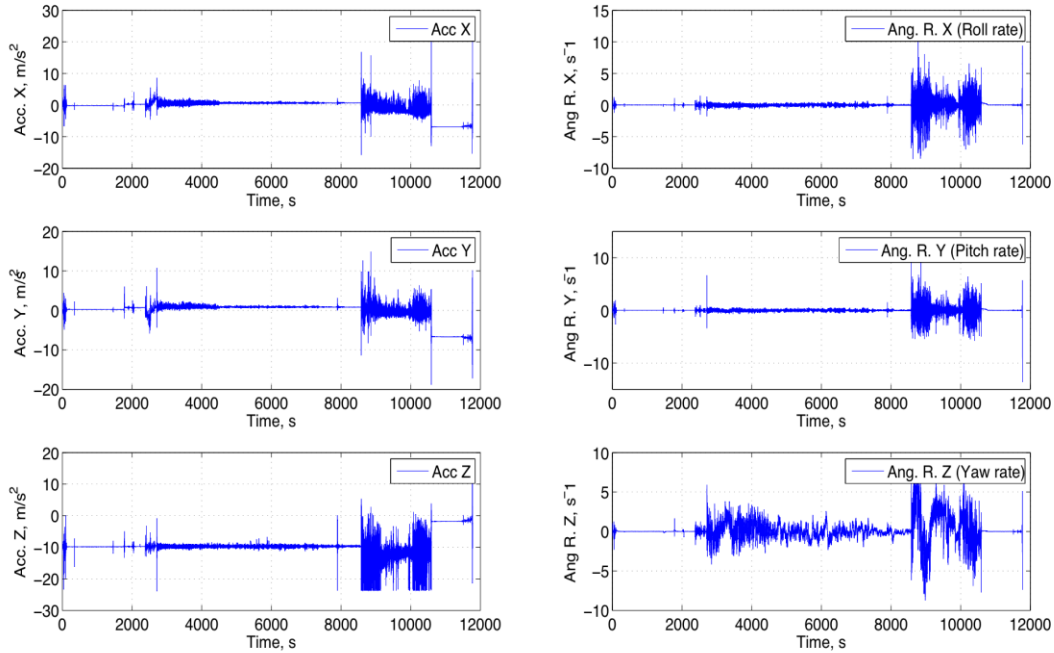


Figure 5.5 illustrating the data collected through the flight.

This data proves to be very valuable as it helps the future flights for the teardrop and the toroidal shaped ballute.

One important device that was used was also the different cutdown mechanisms which proved to be really very helpful. Below its illustrated a figure of what we would like to see in the future for cut down mechanisms. Table illustrating the cutdown voltage used.

Table 5.1 Servo specifications

Operating Voltage Range	4.8 volts – 6.0 volts
Operating Temperature Range	-20° - +60° C
Idle Current	8.8 mA (at 4.8 v), 9.1 mA (at 6.0 v)
Running Current	350 mA (at 4.8 v), 450 mA (at 6.0 v)
Pulse Time	0.9 ms – 2.1 ms

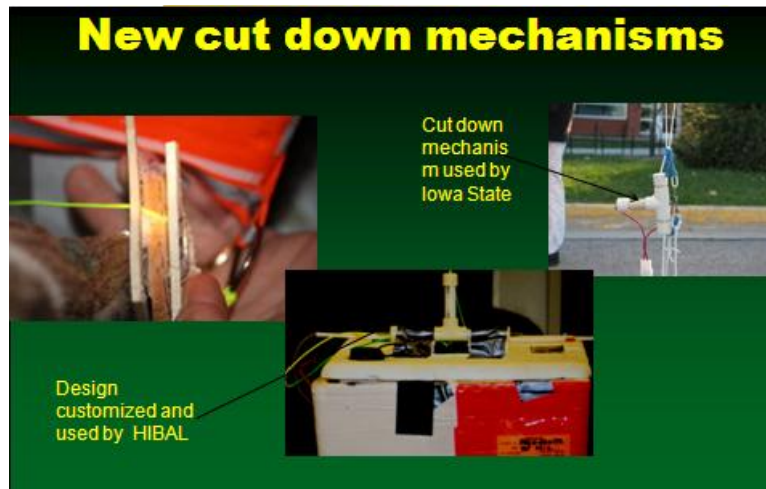


Figure 5.6 illustrating the different cutdown mechanisms the team flew

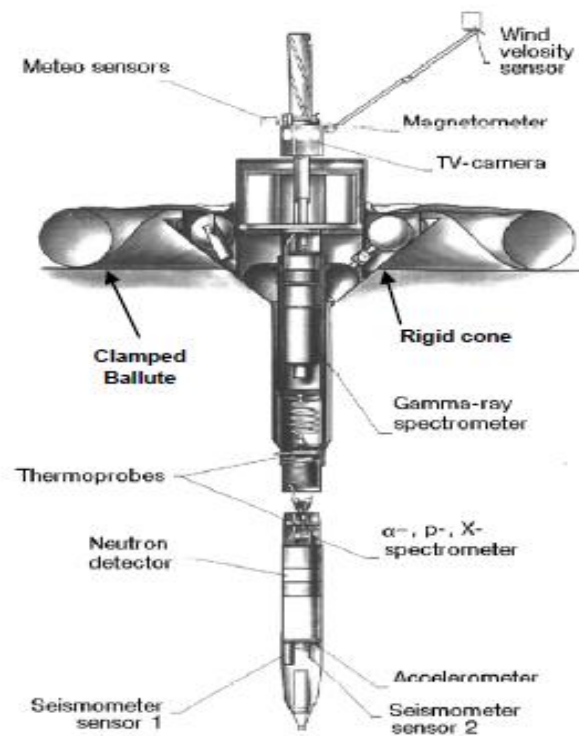


Figure 5.7: Ballute cross-sectional view, Titan experiment 2003 [1].

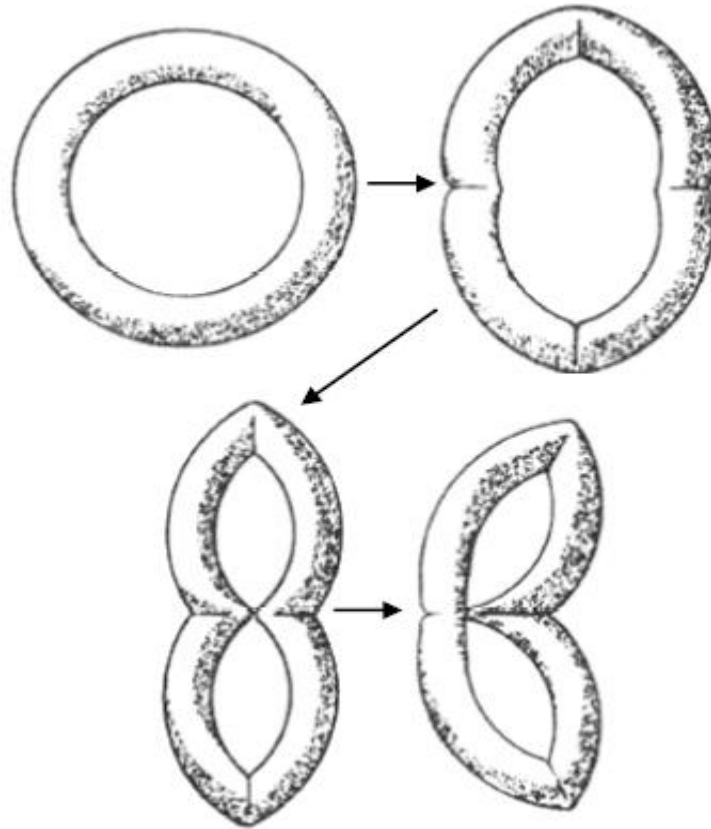


Figure 5.8: pressurized toroidal shape [1].

6.0 Parachute Deployment

6.1 Design 1

It is important for the team to determine a design for the parachute deployment. The goal is to evaluate all of the current designs and pick from the best one. The design being evaluated is as follows. Below there is a picture of one design would look like.

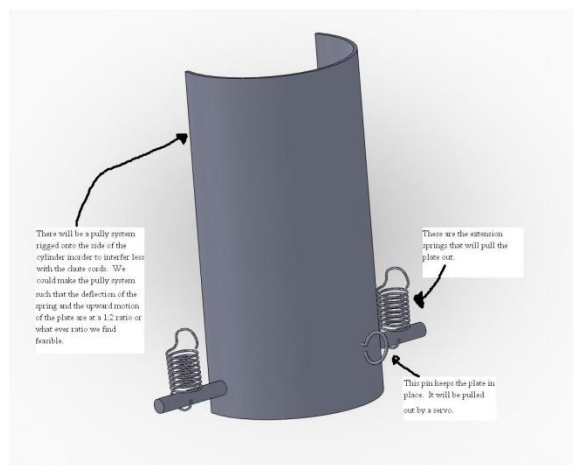


Figure 6.1.1: Design layout of the first choice for the parachute deployment.

Figure 6.1.1, illustrating the first design layout of what is thought to be the first choice for the parachute deployment.

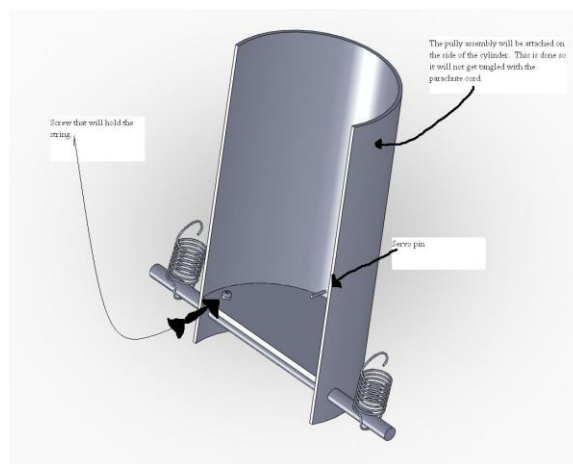


Figure 6.1.2: crosssectional view of the design layout

Figure 6.1.2 illustrating the crosssectional view of the design layout. The design still needs to be decided.

We attached two peice of string to the bottom plate via the screws on the plate. These screws are shown in Drogue chute assembly_2. We then pull the string out of the cylinder and around the pullies that will be attached to the side of the cylinder. The servo pin/pins are then placed into the cylinder to keep the plate from moving up. The string is then attached to the corresponding spring on each side. Now we load the Drogue chute and the main parachute into the cylinder. When we want the chute/chutes to be deployed we just tell the servo to pull the pin/pins.

One of the main advantages to this is the fact that we can change ratio of the displacement of the spring and the upward motion of the plate. For each 1 inch the spring moves, we could have the plate move up 2 inches.

6.2 Design 2

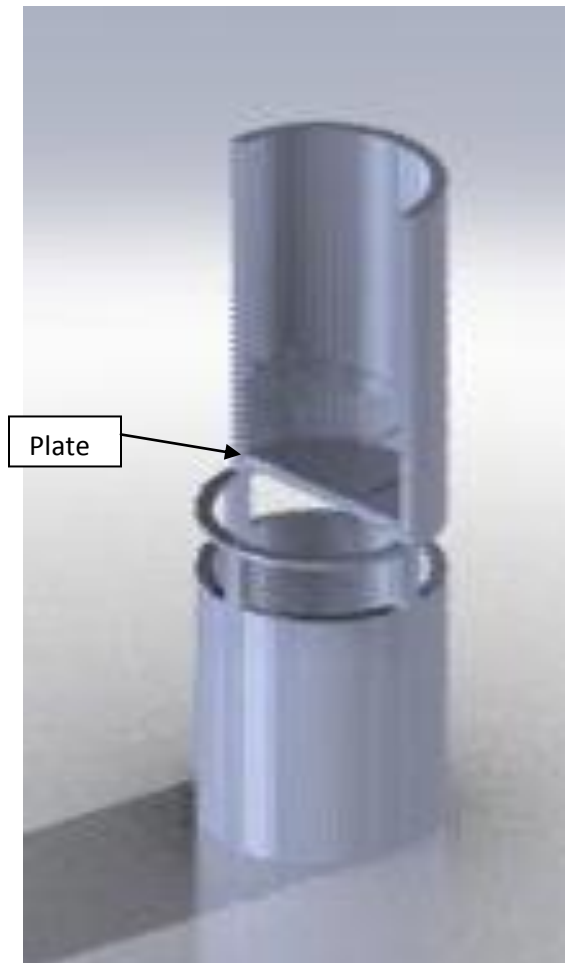


Figure 6.2.1: Cut away view of another design

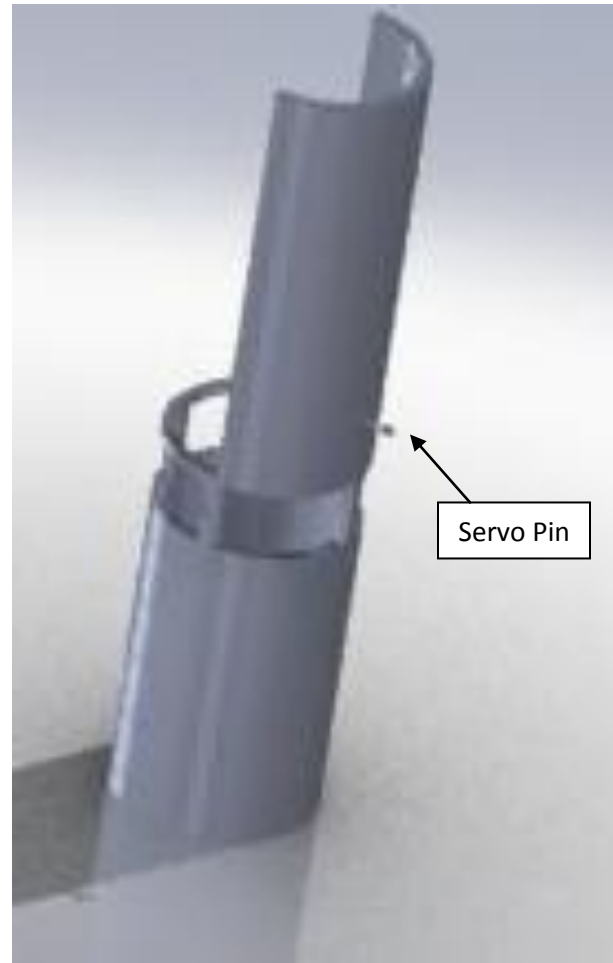


Figure 6.2.4: Back view of the design

Figures 6.2.1 and 6.2.2 shows cut away view and a back view of another potential parachute deployment design. How this one works is there is opening in the middle of the container separating the two chutes. The main chute goes in bottom section and the drag chute is draped over the top of the other section. There is a plate separating the compartments with a servo attached to it. When it is told to the servo removes the plate opening the container allowing air to enter forcing out the drag chute which then pulls out the main chute.

Moreover, it was important for the team to be able to have the most optimal solution for this project. During the time worked on, it another idea was to be able to deploy the parachute through compression springs. The idea would be to put the parachute in a container connected to a drogue chute. The springs would be compressed throughout the flight and when the parachute and drogue chute are ready to deploy we would be cutting the mechanism through NiChrome wire. This is the idea that is most optimal because it allows the team to rely on a drogue chute pull instead of a full parachute. The drogue chute would be the one that would actually pull on the main chute reducing the amount of drag force needed to pull out a main parachute by almost 1/3.

7.0 Radio Tower Antenna

There is going to be a radio tower antenna to be placed on roof of the Russ Engineering Center. The configuration is shown in figure 7.1. One assumption made was that wind velocity is 87 mph keeping it constant for some calculations. Numbers will change with a different wind velocity.

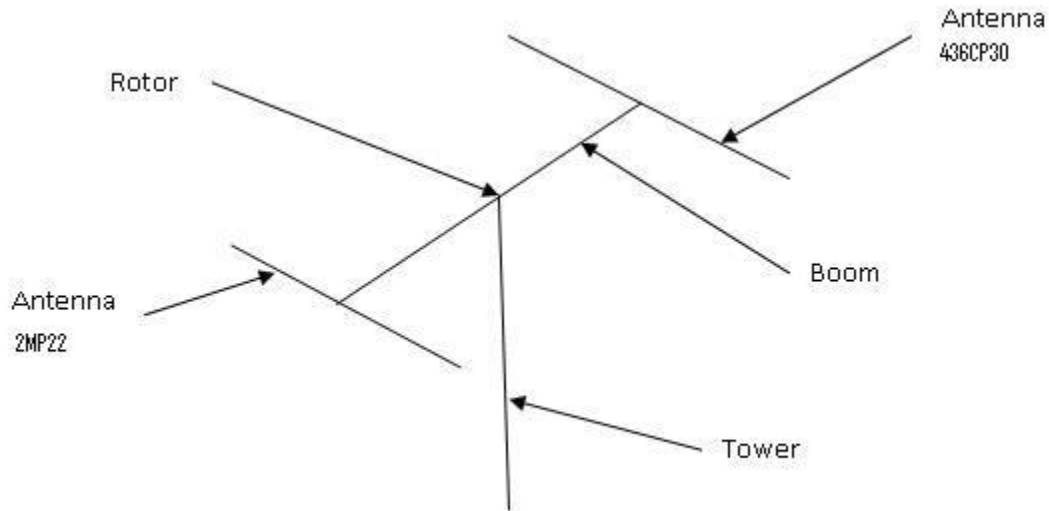


Figure 7.1: Configuration Diagram

The tower by itself has force applied by the wind at a point half way up the tower. The rotor applies a second force at the top of tower. The 2MP22 Antenna applies one load at its end of Boom on the left side. The 436CP30 Antenna applies one load at its end of the Boom on the right side. Calculations are in appendix A.

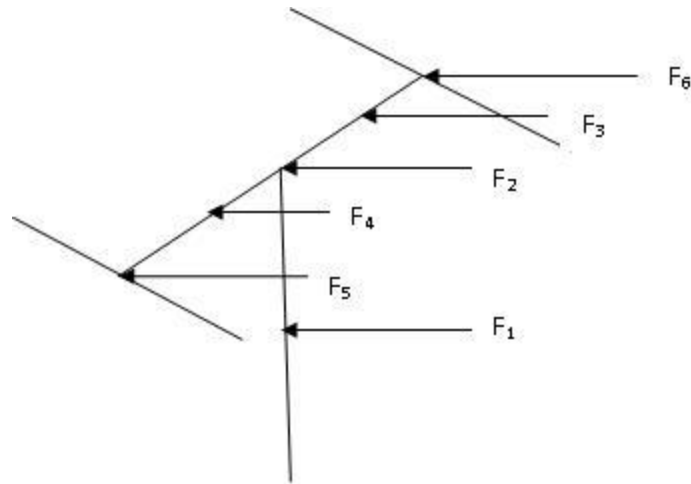


Figure 7.2: Free Body Diagram (FBD)

Conclusion is that Wind will make the tower rotate to the left. Also found out that the Totals are parabolic functions of wind Velocity. 3D Free Body Diagram of the loading is shown in figure 7.2. figures 7.3, 7.4, and 7.5 are plots made in Matlab showing the wind loading is affected by the wind speed.

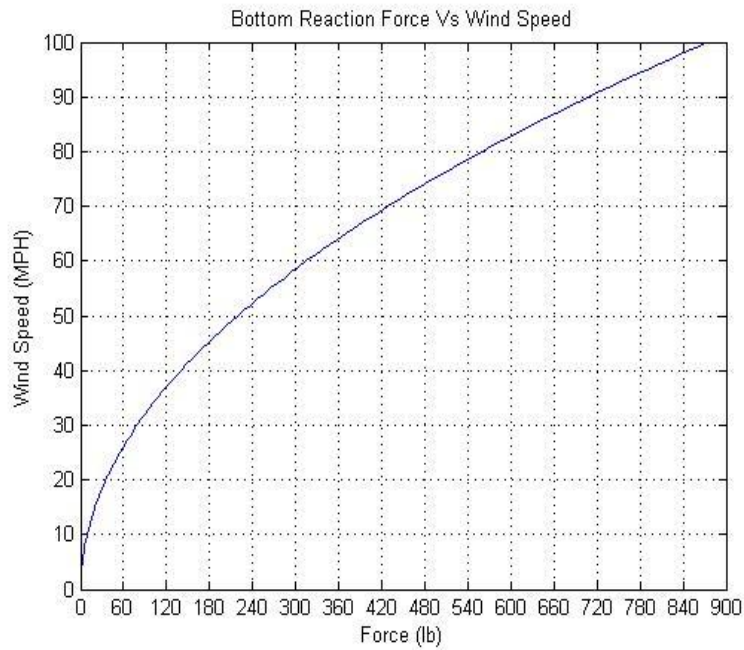


Figure 7.3: Bottom Reaction Force Vs Wind Speed

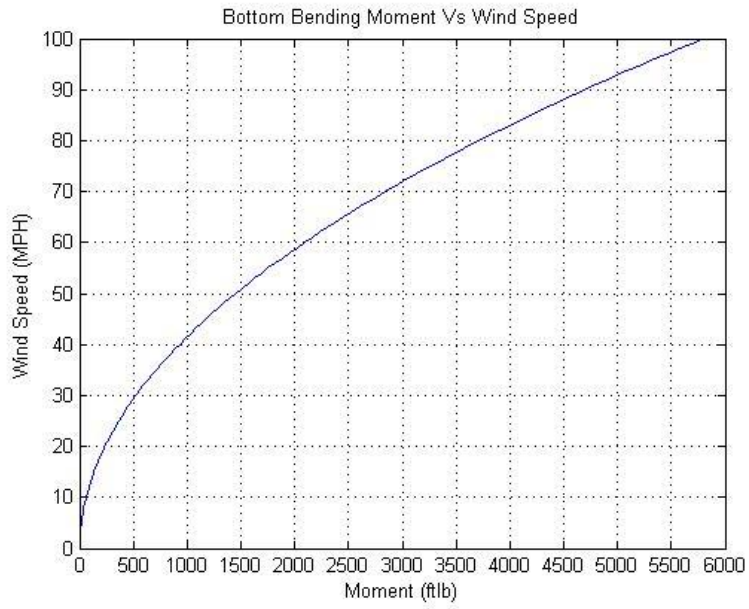


Figure 7.4: Bottom Bending Moment Vs Wind Speed

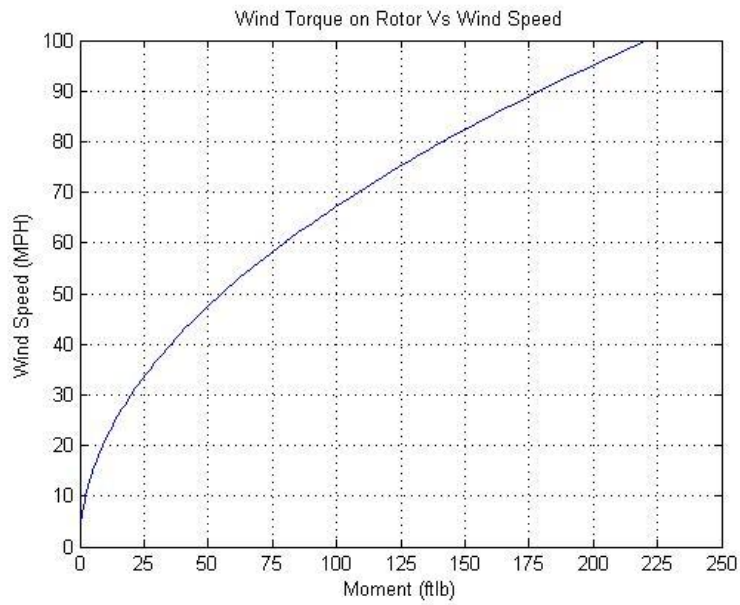


Figure 7.5: Wind Torque on Rotor Vs Wind Speed

8.0 Conclusions

Moreover, some of the issues that the Team is currently facing is the Free Fall testing. The team intends on working on this issue by putting calibrated accelerometers into the system to collect data during free fall. The challenge relies on having the system released whenever the electrical devices tell it to be released. Although, this has been an issue before with the release mechanism not being able to deploy the parachute on time, the Team intends to improve the design of the electrical part of the project before a launch occurs in January.

A few of other restrictions we have to work around are that there is a payload limit of twelve pounds under an unmanned balloon. This is outlined in the FAA regulations subpart D flight regulations. This is a critical parameter as the weight is an issue that the HIBAL team is constantly facing as there is weight that cannot be avoided such as the radio and GPS systems.

Material testing of thin-film polymers for example latex has indicated in the previous teams to be an adequate material to use for the temperatures encountered in the altitude of 60,000 ft and above. The team intends to keep the same material with minimal reinforcements on the shapes tethered attachments.

8.0 References

- (1) Reuben R. Rohrschneider & Robert D. Braun “A Survey Of Ballute Technology For Aerocapture” Georgia Institute of Technology, Guggenheim School of Aerospace Engineering 270 Ferst Dr., Atlanta GA 30332-0150, USA, 2005
- (2) Defense Advanced Research Projects Agency “Rapid Response, Long Endurance Unmanned Aircraft System Program” 3701 N. Fairfax Drive Arlington, VA 22203-1714 November 20,2007
- (3) Wade Pulliam Tactical Technology Office DARPA “Rapid Eye (UAS)” Industry Day July 25, 2007
- (4) WSU “Design of a Re-entry Vehicle for Near Space Experimentation” March 9, 2009
- (5) Tower, http://gmesupply.com/product_info.php/cPath/9/products_id/55948
- (6) Rotor, <http://www.universal-radio.com/catalog/hamrot/0180spec.html>
- (7) Boom, <http://www.m2inc.com/products/acess/hdfgboom.html>
- (8) 2m Yagi Antenna, Circular Polarizing Antenna 2MCP22
<http://www.m2inc.com/products/vhf/2m/2mcp22.html>
- (9) 440MHz antenna, Polarizing Yagi antenna 436CP30
<http://www.m2inc.com/products/uhf/70cm/436cp30.html>
- (10) Tower and Antenna Wind Loading as a Function of Height
By Frank Travanty, July/Aug 2001, <http://www.arrl.org/qex/1123.pdf>

Appendix

A. Radio Tower Wind loading Calculations

A.1 Equations & Terms:

(assumption) $V = \text{Wind Velocity} = 87 \text{ (mph)}$

$A_i = \text{Crossectional Wind Area (ft}^2\text{)}$

$F_i = \text{Force} = \frac{V^2 A_i}{390} \text{ (lbf)}$

$H_i = \text{Height (ft)}$

$d_i = \text{distance from the roof to the force (ft)}$

$d_{ci} = \text{distance from top center or the Rotor (ft)}$

$W_i = \text{Weight (lbf)}$

$$W_T = \text{Total Weight} = \sum_{i=1}^5 W_i \text{ (lbf)}$$

$$R = \text{Reaction loading} = \sum_{i=1}^6 F_i \text{ (lbf)}$$

$$M_o = \text{Total Moment At the bottom of the Tower} = \sum_{i=1}^6 M_{oi} = \sum_{i=1}^6 F_i d_i = \sum_{i=1}^6 \frac{V^2 A_i}{390} d_i \text{ (ft} \cdot \text{lb)}$$

$$M_c = \text{Top Center Wind Torque on the Rotor} = \sum_{i=3}^6 F_i d_{ci} = \sum_{i=3}^6 \frac{V^2 A_i}{390} d_{ci} \text{ (ft} \cdot \text{lb)}$$

A.2 Tower

$$H_1 = 9 \text{ ft}$$

$$d_1 = \frac{H_1}{2} = \frac{9}{2} \text{ ft} = 4.5 \text{ ft}$$

$$A_1 = 18 \text{ ft}^2$$

$$W_1 = 54 \text{ lbf}$$

$$F_1 = \frac{V^2 A_1}{390} = \frac{(87)^2 (18)}{390} = 349.34 \text{ lbf}$$

$$M_{o1} = F_1 d_1 = (349.34 \text{ lb})(4.5 \text{ ft}) = 1572.023 \text{ ft} \cdot \text{lb}$$

A.3 Rotor

$$d_2 = H_1 = 9 \text{ ft}$$

$$A_2 = 1 \text{ m}^2 = 10.764 \text{ ft}^2$$

$$W_2 = 20 \text{ lbf}$$

$$F_2 = \frac{V^2 A_2}{390} = \frac{(87)^2 (10.764)}{390} = 208.903 \text{ lbf}$$

$$M_{o2} = F_2 d_2 = (208.903 \text{ lb})(9 \text{ ft}) = 1880.124 \text{ ft} \cdot \text{lb}$$

A.4 Boom

$$L_3 = L_4 = 60 \text{ in} = 5 \text{ ft}$$

$$D = \text{diameter} = 2.25 \text{ in}$$

$$d_3 = d_4 = H_1 = 9 \text{ ft}$$

$$A_3 = A_4 = (60 \text{ in})(2.25 \text{ in}) = .9375 \text{ ft}^2$$

$$F_3 = F_4 \rightarrow F_3 + F_4 = 2 \frac{V^2 A_{3,4}}{390} = 2 \frac{(87)^2 (.9375)}{390} = 2(18.195 \text{ lbf})$$

$$M_{o3} = M_{o4} \rightarrow M_{o3} + M_{o4} = 2(F_3 + F_4)d_{3,4} = 2(18.195 \text{ lb})(9 \text{ ft}) = 2(163.75 \text{ ft} \cdot \text{lb})$$

$$d_{c3} = d_{c4} = \text{distance from center} = \frac{60+18}{2} \text{ in} = 39 \text{ in} = 3.25 \text{ ft}$$

$$M_{c3} = -M_{c4} \rightarrow M_{c3} - M_{c4} = 0 \rightarrow M_{c3} = F_3 d_{c3} = (18.195 \text{ lb})(3.25 \text{ ft}) = 59.13 \text{ ft} \cdot \text{lb}$$

A.5 2m Yagi Antenna, Circular Polarizing Antenna 2MCP22

$$L_5 = 18 \text{ ft } 7 \text{ in} = 18.583 \text{ ft}$$

$$d_5 = H_1 = 9 \text{ ft}$$

$$A_5 = 2.5 \text{ ft}^2$$

$$W_5 = 12.5 \text{ lbf}$$

$$F_5 = \frac{V^2 A_5}{390} = \frac{(87)^2 (2.5)}{390} = 48.52 \text{ lbf}$$

$$M_{o5} = F_5 d_5 = (48.52 \text{ lb})(9 \text{ ft}) = 436.673 \text{ ft} \cdot \text{lb}$$

$$d_{c5} = \left(60 + \frac{18}{2}\right) \text{ in} = 69 \text{ in} = 5.75 \text{ ft}$$

$$M_{c5} = F_5 d_{c5} = (48.52 \text{ lb})(5.75 \text{ ft}) = 278.986 \text{ ft} \cdot \text{lb}$$

A.6 440MHz antenna, Polarizing Yagi antenna 436CP30

$$L_6 = 117 \text{ in} = 9.75 \text{ ft}$$

$$d_6 = H_1 = 9 \text{ ft}$$

$$A_6 = 1 \text{ ft}^2$$

$$W_6 = 5 \text{ lbf}$$

$$F_6 = \frac{V^2 A_6}{390} = \frac{(87)^2 (1)}{390} = 19.408 \text{ lbf}$$

$$M_{o_6} = F_6 d_6 = (19.408 \text{ lb})(9 \text{ ft}) = 174.669 \text{ ft} \cdot \text{lb}$$

$$d_{c6} = d_{c5} = 69 \text{ in} = 5.75 \text{ ft}$$

$$M_{c6} = F_6 d_{c6} = (19.408 \text{ lb})(5.75 \text{ ft}) = 111.594 \text{ ft} \cdot \text{lb}$$

A.7 Totals

$$R = \sum_{i=1}^6 F_i = (349.34 + 208.903 + 48.52 + 19.408 + 2 * 18.195) \text{ lbf} = 662.557 \text{ lbf}$$

$$W_T = \sum_{i=1}^6 W_i = (5 + 12.5 + 20 + 54) \text{ lbf} = 91.5 \text{ lbf}$$

$$M_{o_T} = \sum_{i=1}^6 M_{o_i} = (1572.023 + 1880.124 + 436.673 + 174.669 + 2 * 163.75) \text{ ft} \cdot \text{lb} = 4391 \text{ ft} \cdot \text{lb}$$

$$M_{c_T} = M_{c_5} - M_{c_6} = (278.986 - 111.594) \text{ ft} \cdot \text{lb} = 167.39 \text{ ft} \cdot \text{lb}$$

$$M_{c_T} = F_5 d_{c5} - F_6 d_{c6} = \frac{V^2 A_5}{390} d_{c5} - \frac{V^2 A_6}{390} d_{c6} = \frac{V^2}{390} (A_5 d_{c5} - A_6 d_{c6})$$

A.8 Matlab Code for Wind loading

```
%Radio Tower & Antenna Wind Loading
clc;clear;close all
V=(1:100)';
H=9;
D=2.25/12;
L=5;
dc=L+18/12/2;
A=[18, (1/.0254/12)^2, 2*D*L, 2.5, 1]';
F=zeros(length(V),length(A));
for i=1:length(A)
    F(:,i)=V.^2*A(i)/390;
end
sF=sum(F,2);
M(:,1)=F(:,1)*4.5;
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for i=2:length(A)
    M(:,i)=F(:,i)*H;
end
sM=sum(M,2);
Mc(:,1:2)=F(:,4:5)*dc;
sMc=Mc(:,1)-Mc(:,2);
figure(1)
plot(sF,V);grid
title('Bottom Reaction Force Vs Wind Speed')
xlabel('Force (lb)')
ylabel('Wind Speed (MPH)')
set(gca,'xtick',0:60:1000)
figure(2)
plot(sM,V);grid
title('Bottom Bending Moment Vs Wind Speed')
xlabel('Moment (ftlb)')
ylabel('Wind Speed (MPH)')
set(gca,'xtick',0:500:10000)
figure(3)
plot(sMc,V);grid
title('Wind Torque on Rotor Vs Wind Speed')
xlabel('Moment (ftlb)')
ylabel('Wind Speed (MPH)')
set(gca,'xtick',0:25:300)

```

B. Balloon Fill Calculations in Matlab

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% Balloon filling calculations
% Caleb Barnes 2008
% Adapted from hab_Vol_gas_burst_press created by Brandon Kirby 2006

clear all; clc; close all;

disp('-----Inputs-----')

% Input launch conditions and initial conversions
Ta = input('\nInput ground surface temperature (C): ');
Ffe = input('\nInput system weight (lb) (everything except balloon): ');
Mb = input('\nInput mass of balloon (kg): ');
disp(' ')
disp('Input burst diameter of balloon (ft): ');
disp('1500g balloon: 27ft');
disp('2000g balloon: 30ft');
burst_de = input('3000g balloon: 35ft \n');

Wb = 2.20462262*Mb; %Convert mass to lb
Ffe = Ffe + Wb; %Add weight of balloon to system weight
Ff = Ffe*(1/.224809);%Convert payload weight to Newtons;

% Find the density of helium and air at ground temp and pres
rhohe = (101.4*10^3)/((2.0769*10^3)*(273+Ta));%kg/m^3
roa = (101.4*10^3)/((.2870*10^3)*(273+Ta));%kg/m

% Calculate balloon volume (assuming elastic effects negligible)

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% This section calculates volume to obtain equilibrium
V = Ff/((roa-rohe)*9.81);%in m^3
Venglish = V*35.3147; %Convert to ft^3
Vliters = V*1000; %Convert to Liters
ground_d = 2*(3/(4*pi)*Venglish)^(1/3); %ground diameter in inches

disp('-----Outputs-----')
% Compensate for lift required to obtain 1000 ft/min ascent rate
% Based on reference sheet provided by Hank Riley, N1LTV with LIFTWIN v1.02
% This information included at the end of the program
if (ground_d < 3.5)
    Ffe = Ffe + 0.7;
elseif ((ground_d > 3.5) && (ground_d < 4.5))
    Ffe = Ffe + 1.2; FL = 1.2;
elseif ((ground_d > 4.5) && (ground_d < 5.5))
    Ffe = Ffe + 1.9; FL = 1.9;
elseif ((ground_d > 5.5) && (ground_d < 6.5))
    Ffe = Ffe + 2.7; FL = 2.7;
elseif ((ground_d > 6.5) && (ground_d < 7.5))
    Ffe = Ffe + 3.7; FL = 3.7;
elseif (ground_d > 7.5)
    Ffe = Ffe + 4.8; FL = 4.8;
end

% Recalculate volume with compensated free lift
Ff = Ffe*(1/.224809);
V = Ff/((roa-rohe)*9.81);
Venglish = V*35.3147;
Vliters = V*1000;
Vfm = 1.398*(Vliters) + 0.4675; %Compensated for flow meter reading
ground_d = 2*(3/(4*pi)*Venglish)^(1/3);

% Display results
fprintf ('\nFinal lift force needed: %6.2f lb', Ffe)
fprintf ('\nFree lift required for balloon size: %4.1f lb\n',FL)
fprintf ('\nVolume required: %6.2f L, or %6.2f ft^3',Vliters,Venglish)
fprintf ('\nBalloon ground diameter: %3.2f ft\n',ground_d)
fprintf ('\nCompensated flow meter reading: %6.0f L\n',Vfm)

% Find the balloon burst altitude
m = V*rohe;%Mass of helium inside balloon in kg
burst_d = burst_de*0.3048; %Convert bd to meters
r = burst_d/2; %Radius of balloon at burst
Talt = 253; %K %-20C Approximate temperature at max altitude
Vb = (4/3)*pi*(r^3);%Balloon burst volume in m^3
P = m*(2.0769*10^3)*Talt/Vb; %Pa
Pk = P/1000; %kPa

%altitude data pulled from http://www.sablesys.com/baro-altitude.html
if Pk<7.24 && Pk>4.49, %60K to 70K
    ah = 70000;
    al = 60000;
    Ph = 4.49;
    Pl = 7.24;
    Altitude = (ah - al)*((Pk - Pl)/(Ph - Pl)) + al; %feet
end

```

