Near Space Balloon Initiative 2011

A challenging endeavor for Carnegie Mellon SEDS

Contents of Program Requirements

1. Program Overview

The primary goal of the Near Space Balloon Initiative (NSBI) is to convince students that space is closer and more obtainable then conventionally believed. Using easily obtained materials, students are tasked to photograph the surface of the Earth and the blackness of Space from an altitude of 19 miles. Students will use a digital camera and a sounding balloon in this proposal. Award Fees will be granted if students successfully complete one or more of the bonus challenges (listed in section 7). However, to receive funding, students must adhere to all of the program requirements.

Remember that the Near Space Balloon Initiative is meant to be a fun team building project. Please do not become too caught up with the rules and regulations! They are there to make sure you think of all subsystems and their associated issues.

Please direct any questions or comments to:

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2. Electronics

Section 2.1 - Camera Electronics

2.1.1 Camera must photograph images with a resolution of 2.0 mega-pixels or greater.

2.1.2 Camera must take photographs at an interval of 5 minutes or less. Continuous video is also acceptable.

2.1.3 Camera must photograph from initial launch until apogee (~3.5 hours). Post apogee filming is acceptable.

2.1.4 Camera must have an appropriate amount of memory to store all required images (or video).

2.1.5 Camera must successfully focus on the Earth to create crisp images.

2.1.6 Camera must deal with the lighting contrast between the bright Earth and dark space.

2.1.7 Camera must not be vulnerable to humidity induced image distortion.

2.1.8 Camera must have adequate electrical power to successfully complete mission.

Section 2.2 – Recovery Electronics

2.2.1 A GPS system must be implemented to successfully retrieve the camera unit.

2.2.2 The GPS system must communicate to the user where the camera unit is located (i.e. Google Maps application).
2.2.3 The GPS system must be able to contact cell phone towers or satellites no matter where the camera unit lands.
2.2.4 The GPS system must have enough electrical power to actively perform its duty for no less than 24 hrs.
2.2.5 The GPS system must comply with FAA regulations.

3. Mechanics

Section 3.1 – Recovery Components

3.1.1 The Near Space Unit will deploy a properly sized parachute at the apogee.
3.1.2 The recovery parachute must be designed to prevent any gravity induced damage to the Near Space Unit and limit damage done to private property.
3.1.3 The recovery parachute must be a vivid color. This will aid in unit retrieval.
3.1.4 The Near Space Unit must be a vivid color. This will aid in unit retrieval.
3.1.5 The base of the Near Space Unit must be designed in such a manor to ensure the Recovery Electronics' Signals can successfully communicate its position upon landing. (For example, the GPS still faces the sky after the Near Space Unit has a hard touch down).
3.1.6 The Recovery Team must prepare for the event of the unit getting caught in a tree upon decent. Methods for easy tree recovery should be explored.

Section 3.2 – Thermal Management

3.2.1 The electronic bay must be thermally managed to mitigate damage to electronic components. Freezing temperatures slow the chemical reaction in batteries, causing a loss in power supply.

Section 3.3 – Water Resistance

3.3.1 The design of the electronics bay must consider the event of a crash landing into a shallow body of water. The event of a deep water landing is not considered.
3.3.2 The design of the electronics bay must consider the unit being recovered after a rain storm.

Section 3.4 – Balloon Sizing

3.4.1 The balloon must be sized large enough to ensure the Near Space Unit reaches the required altitude (listed in the Program Overview) within a reasonable amount of time. The larger the balloon, the more buoyancy force the Near Space Unit experiences, causing a faster rise time. This will also limit the electronics to temperature extremes.

3.4.2 The balloon must not be sized too large, preventing the balloon from reaching the required altitude (listed in the Program Overview). Because of the delta P between the balloon gas and the Near Space Atmosphere, balloons with too much buoyancy gas can prematurely pop.

Section 3.5 – Flight Trajectory Prediction

3.5.1 Using a force balance on the balloon and Newton's Second Law of Motion, the team must create a Matlab simulation to roughly estimate altitude vs. time.

3.5.2 Empirical sphere drag coefficients, the density of air as a function of altitude, and the diameter of the balloon as a function of altitude (if possible) will be used to determine the drag force during ascent.

3.5.3 Students will assess whether the change in gravitational force with altitude can be neglected from this simulation.

3.5.4 Empirical parachute drag coefficients, the density of air as a function of altitude, and the diameter of the parachute will be used to determine the drag force during descent.

3.5.5 The simulation will cut the flight up into small delta times (dt). At the beginning of each time step, the program will assess the buoyancy force, drag force, and gravitational force to find the appropriate acceleration. This acceleration (assumed to be constant over each dt) will be integrated over the time step to determine the change in velocity (dv) and the change in altitude (dx). Adding these changes to their respective initial values, the final velocity and altitude of each time step can be found. Plotting these values against time will provide a flight profile.

3.5.6 Students will use an internet balloon flight predictor to determine the balloon's horizontal displacement from the launch site. This will aid in predicting the launch site and landing location.

4. Safety

Section 4.1 – FAA Regulations

4.1.1 The Near Space Balloon will follow all applicable FAA sounding balloon regulations.
4.1.2 The Near Space Balloon must not interfere with airplanes.
4.1.3 The Near Space Balloon Recovery Electronics should follow FAA transmitting signal regulations. There might be rules determining the maximum height of signal producing devices.
4.1.4 The Near Space Balloon must be under FAA weight regulations.
4.1.5 The Near Space Balloon must abide to FAA weight-to-area regulations.
4.1.6 The Near Space Balloon must follow FAA recovery regulations.

5. Timeline

Section 5.1 – Bi-Monthly Teleconferences

5.1.1 Students will communicate with the NSBI coordinator, Matthew Kuhn, at a minimum of twice a month. The conferences are meant for the team to share design and analysis updates. The conferences are also a good time to ask for advice (if needed).
5.1.2 The preferred method of communication is Skype. However, other forms of communication are acceptable.
5.1.3 PowerPoint presentations depicting recent activity are highly encouraged, but not mandatory.

Section 5.2 – Preliminary Design Review (PDR)

5.2.1 The Preliminary Design Review is a benchmarked date in which the team presents their initial design. The PDR is where the team discusses how the requirements will functionally be met. The program coordinator will provide feedback on the design and determine whether it is appropriate to move to the next phase of design.
5.2.2 The PDR will happen no later than one month after project initiation.
5.2.3 Each team member must present some design aspect of the PDR (if attendance is possible).

Section 5.3 – Critical Design Review (CDR)

5.3.1 The Critical Design Review is a benchmarked date in which the team presents their final design. The CDR is where the team presents the final design, specific components used, operational procedures, and total cost. How the design fits all

of the program requirements will be discussed. The program coordinator will provide feedback on the design and determine whether it is appropriate to purchase parts and begin construction.

5.3.2 The CDR will happen no later than one month after the PDR.

5.3.3 Each team member must present some design aspect of the CDR (if attendance is possible).

Section 5.4 – Flight Hardware Test

5.4.1 The Near Space Unit will be tested in Near Space conditions before launch, ensuring correct component operation. This test can be conducted in a freezer.

5.4.2 A test must prove the Near Space Unit can survive Near Space conditions for at least 2.5 hours.

5.4.3 A test must prove the Near Space Unit can photograph images for at least 3.5 hours. Part of this test must include requirement 5.4.2.

Section 5.5 – Launch Day

5.5.1 The Final Launch day must be before May 10th (negotiable due to short timeline).

5.5.2 The team must notify the program coordinator 2 weeks prior to intended launch.

6. Funding

Section 6.1 – Boeing

6.1.1 Matt Kuhn guarantees to reimburse CMU SEDS up to $350 for material costs.

6.1.2 All receipts must be submitted in order to receive reimbursement.

6.1.3 Checks from Matt Kuhn will be mailed out no later than one week after final expense report and receipts are received.

6.1.4 The Maximum Boeing stipend fund (mentioned in 5.1.1) is liable to change if funding from other sources is obtained.

Section 6.2 – Student Senate

6.2.1 Students are encouraged to talk to CMU Student Senate and ask for funding. Due to long response times, students must apply to Student Senate as soon as possible.

6.2.2 An Oracle account might be required to receive funding.

6.2.3 In order to maximize chance of Student Senate funding, the presenting team must convince Senate of the following:

- The Project will have a positive impact upon campus.
- All campus students are welcome to join the team.
- Upon successful completion of the project, there will be an info session presenting all results and lessons learned.
- Sufficient advertisement will be posted to inform students of all the above.
- This project will have a positive educational impact on all involved members.
- The requested funding is a one time only acquisition. It not only benefits campus, but will help kick off CMU SEDS.
- To demonstrate project sincerity, discuss how other funding options are being pursued. However, say the funding is still in question and any additional money would help. Student Senate wants to see that all options are being looked at; however, if you receive to much additional funding, their funding might be limited.

Section 6.3 – Mechanical / Electrical Departments

6.3.1 It is suggested to ask departmental heads for NSBI funding. They usually like to support Student Initiatives as long as you don't ask for too much money!

Section 6.4 – Pennsylvania Space Grant Consortium

6.4.1 The Pennsylvania Space Grant Consortium might offer some project funding. Kayla Aloyo would be the most knowledgeable in this area.

Section 6.5 – Expense Reports

6.5.1 To receive Boeing reimbursement, a detailed expense report must be created.

6.5.2 An expense report in Excel format is preferred.

6.5.3 The expense report must detail every product's supplier and price.

6.5.4 The expense report must include all receipts.

7. Bonus

Section 7.1 – Rocket Launch

7.1.1 CMU SEDS will receive an extra $75 for successfully launching a retrievable camera rocket from the Near Space Unit at balloon apogee.

7.1.2 The rocket must be powered by a standard motor of 'D' impulse or higher.

7.1.3 The rocket must contain a camera unit and a GPS Unit.
7.1.4 The rocket is suggested to follow all FAA regulations.
7.1.5 The camera on the rocket must be aft facing, in order to film departure from sounding balloon.

Section 7.2 – SEDS Emblem

7.1.1 CMU SEDS will receive an extra $20 for successfully photographing (i.e. in focus and no humidity blurring) the emblem of CMU SEDS with the surface of the Earth and the blackness of Space in the background.

Section 7.3 – Matt Kuhn Photograph

7.1.1 CMU SEDS will receive an extra $20 for successfully photographing (i.e. in focus and no humidity blurring) a picture of Matt Kuhn (provided upon bonus pursuance) with the surface of the Earth and the blackness of Space in the background.

Section 7.4 – Moon Photograph

7.1.1 CMU SEDS will receive a one-time-bonus of $20 for successfully photographing (i.e. in focus and no humidity blurring) the moon in any of CMU SEDS Near Space Balloon apogee photos.