BalloonSat Competition Event Qualifying Rulebook

Organised by

antariksha labs

Background of BalloonSat

The BalloonSat design evolved from CanSat, a project conceived by Professor Bob Twiggs at Stanford University's Space Science Development Laboratory. The original CanSat included an auxiliary EEPROM memory chip for data storage and a modem (modulator-demodulator) to allow connection to an external radio transmitter and receiver which was used to feed in live data to the ground station. This helped a lot for testing the payloads before launching it in actual space capsules.

The BalloonSat eliminates the limitations of CanSat, and provides a number of enhancements like near space environments situation. Balloonsat has been prominently used by space organizations like NASA, ISRO, DRDO etc. to test the model payloads. It has been a great platform to test space experiments and this event provides a vital step towards providing the same for you students.

What is a BalloonSat?

BalloonSat, also known as "near space satellites", are high altitude research platforms for student created payloads. BalloonSat is a simple package designed to carry lightweight experiments into near space. They are a popular introduction to engineering principles in some high school and college courses. BalloonSats are carried as secondary payloads on ARHAB flights. One reason BalloonSats are simple is because they do not require the inclusion of tracking equipment; as secondary payloads, they already are being carried by tracking capsules.

Often the design of a BalloonSat is under weight and volume constraints. This encourages good engineering practices, introduces a challenge, and allows for the inclusion of many BalloonSats on an ARHAB flight. The airframe material is usually Styrofoam or Foamcore, as they are lightweight, easy to machine, and provide reasonably good insulation. Most carry sensors, data loggers and small cameras operated by timer circuits. Popular sensors include air temperature, relative humidity, tilt, acceleration, Geiger counters, EMF measurement instruments, Biological equipment, Gases measurement equips etc... Experiments carried inside BalloonSats have included such things as captive insects and food items even.

Before launch, most BalloonSats are required to undergo testing. These tests are designed to ensure the BalloonSat will function properly and return science results. The tests include a cold soak, drop test, function test, and weighing. The cold soak test simulates the intense cold temperatures the BalloonSat will experience during its mission. A launch and landing can be traumatic, therefore the drop test requires the BalloonSat to hold together and still function after an abrupt drop. The function test verifies the BalloonSat crew can prep the BalloonSat at the launch site.

Overview

It costs 6 lakhs per kilogram of weight to launch a satellite into Earth orbit. The cost of a CubeSat kit, the smallest functional satellite, is in the tens of thousands of lakhs. So many students build BalloonSats in their place. BalloonSats are a viable alternative to making and launching satellites. First, they operate just like satellites. However, they are constructed from inexpensive off-the-shelf materials Second, their launch and flight are inexpensive because they are launched on helium-filled weather balloons. Weather balloons can lift them to altitudes in excess of 100,000 feet. Altitudes above 60,000 feet is called near space and this region of the atmosphere is more similar to outer space than to the surface of Earth. To behave like a satellite, the BalloonSat must carry one or more experiments. Those experiments may actively acquire data or be passive exposure experiments. The data collected is stored onboard until the BalloonSat is recovered after its mission. There are some BalloonSat designs that transmit data during flight, but this is rare in comparison to the total number of BalloonSats that fly. The launch of the weather balloon can subject the BalloonSat to a lot of forces. The same is true when the balloon bursts and the BalloonSat begins returning to Earth. The BalloonSat must be designed to properly hold together during these conditions. The near space environment is intensely cold, near vacuum, and has higher radiation levels. The BalloonSat has to be designed to function properly in these conditions.

Parts of a BalloonSat

There are two major parts of a BalloonSat.

- The first is the airframe. This is the body of the BalloonSat. Its function is to hold all the parts together and to protect the items inside the BalloonSat.
- The second is the avionics. This is the electronic systems inside the airframe. Its function is to control the operate of the mission. Avionics may be a simple datalogger that only record the voltages of sensors or it may actively control experiments.

Possible Design Limitations

Just like real satellites, there may be limitations in your BalloonSat project. Here is a list of possible limitations that may apply to your project.

- Maximum Weight
- Experiment Requirements
- Minimum Amount of Data and Frequency of Data Collection
- Available Design and Build Time
- Maximum Dimensions

Design Considerations

Before beginning to make your BalloonSat, keep these points in mind. By heeding them, your BalloonSat will be easier to fly and more likely to return the data you expect. Give your BalloonSat sufficient volume that you can easily install all its components. At that same time, don't waste an excessive amount of material making the BalloonSat hugely larger than necessary. A mission can be rough, make sure batteries and electronics cannot break free or shake loose.

A BalloonSat is connected to the balloon through tethers. Tethers are thin cords or strings that could cut through the airframe material. Therefore your BalloonSat design needs to incorporate plastic tubes for the tethers to run through (tether raceways). A single tether will let your BalloonSat spin like a top and doesn't provide for redundancy. At the launch site, you will need to perform a final check and prep on your BalloonSat. Therefore, create at least one hatch in your BalloonSat that allows you to easily access the battery snap and battery box. Place the hatch on the side of the BalloonSat. The tethers are located on the top and bottom of the BalloonSat and they will interfere with opening and closing the hatch, if the hatch is not located on the side of the BalloonSat.

Here are more considerations to keep in mind. It's intensely cold in near space. So it is important that the airframe have openings only as large as needed. Any larger and the interior may get too cold. Items like cameras must be bolted to the BalloonSat airframe. To make the attachment of the camera more secure, make the diameter of the bolt hole through the airframe the same size as the bolt's diameter. Adding washers to bolt heads and nuts spreads out the force they create on Styrofoam. The reduced pressure reduces the risk of crushing the airframe. Do not add a clear window over a lens opening in the airframe. We instinctively want to cover the openings in airframes to reduce the amount of cold air entering the airframe. However, windows are locations where condensation forms and this results in the foggy of windows over camera lens. At the time of launch and balloon burst, BalloonSats get shaken up pretty badly. Design your BalloonSat so that cameras, sensors, batteries, and avionics will not break free and either bounce around inside the airframe, or get ejected from the airframe.

On the morning of launch, you won't have a lot of time to prep your BalloonSat. Therefore, place access hatches on the side of the BalloonSat and out of the way of the tethers. Also, design the hatch be to quickly opened and closed. This is even more important when the BalloonSat will be launched on a cold morning. A rubber band closure is an easy to quickly open and close the hatch. Rubber bands can be secure as long as every item is secured inside the BalloonSat and the rubber band is only holding a lightweight hatch in place. Many modern cameras have power save features that prevent the batteries from running down when the camera is not being used. This feature should be turned off. No one can restart a camera that has switched itself off in near space.

From the electronics side, your experiment has to be well isolated from the outside temperature otherwise your system might tend to fail. Proper RF modules must be used for data communication over HAM Radios. Also look for other options of RF as it's a crucial part for tracking. You will be asked to take a HAM Radio test which will enable you for a lifetime opportunity to get data from active satellites orbiting. Other electronics power budgeting has to be done carefully because the module needs to powered on for the entire span of flight. Use controllers as per your convenience with which you might be familiar like Arduino etc. Other resources will be passed after selections. You can use other material apart from Styrofoam for the structure but do take care of the isolation that is needed for the internal components.

Quick Guide

- The team is required to design the entire module comprising of systems like Payload Unit, On Board Computer & Software Development, Telemetry & GPS Tracking, Command & Data Handling, Ground Station Control, Housekeeping & Descent Control, Power Unit & Circuitry, Structure & Payload Health Unit and others related.

- The main objective of the competition is to launch your designed payload to near space environment with secondary objectives to acquire the Attitude and General sensor data.

- The payload idea and design has to be done and procured by your team which will later be mounted on your fabricated structure model. We are looking for interesting and unique payload idea and the most innovative experiments will make it to top teams for the launch.

- The first step of the launch is to attach the parachute apex point with the hydrogen/ helium filled balloon's shrouds which will take your structure/payload to near space. The BalloonSat structure-payload (Cylinder of 20cm diameter-30cm height & 1kg weight) will be attached to the primary parachute's shrouds.

- The Module has to begin transmitting live payload data to the ground station and the data needs to be displayed graphically as well has to be stored on board for post processing of lost data. GPS tracking sequence also has to be initiated before the launch.

- Upon reaching the final countdown and after launching, the Tracking team has to start monitoring the trajectory of the BalloonSat and follow its trail after the launch for the recovery using GPS trackers, ground station data and radio data. Remember, module can go beyond 50km and you need to have a private taxi with you to recover it and your transmission module has to work to let you launch your module.

- After the crossing of 20 km altitude, the command has to begin for main payload work initiation which carries the maximum marks for the event. Negative marks will be awarded if they start the payload work right from launch. No negative for initiating general sensor data capture from launch period.

- Right after the balloon bursts upon reaching maximum expansion point(30-40km), the role of the descent system begins where the descent rate has to be maintained between 20-25 m/s using parachutes designed by you. The Tracking team need to get super active after this as the descent is going to be very quick.

- Upon descending to an the altitude on 200m, the secondary descent system like parachutes, parafoils, streamers etc. need to eject reducing the drop rate to 2-5m/s.

- The temporary locating beacon i.e. the buzzer has to be of very high intensity and should initiate after crossing 200m mark. The parachute color also should be selected properly so that the module can be located visually very easily.

- After successful recovery of the module, the team need to get back to launch site for data collection and after that the team will be given 1 day time to prepare the Post Flight Review.

- Collective marks of Preliminary Design Review, Critical Design Review, Launch Achievements and Post Flight Review will decide the winner of the competition.

Abstract Submission Rules

Getting Started

Important factors in developing a winning proposal with a high probability of completion include:

- Quantifying expected behavior.
- Demonstrating that the effect can be measured or observed.
- Planning for pre-flight testing to verify successful operation during the flight.
- Planning how to analyze the resulting data.
- An experiment: with a hypothesis to test, usually with controls and a conclusion about the validity of the hypothesis.
- An observation: establish how the observation will be quantified with sufficient precision and accuracy.
- A demonstration: design a way to accomplish the task.

A possible approach to developing the project:

- Hold brain storming sessions to determine ideas and interests. Don't discard impossible ideas; they might lead to other ideas or be refined later.
- Hold a session to select a few of the ideas to pursue in depth and discuss how you might implement them.
- Learn enough about the proposed project to identify requirements for completion, especially sensitivity requirements. Identify hardware and instrumentation necessary for completion.
- Develop a proposal following the outline beginning on this page, through page .
- Submit proposal as detailed on page .

Proposal Format Requirements

A successful project proposal will demonstrate that the student team members understand the scientific and engineering principles involved in the proposal and that resources are available for successful completion of the project. Teams must show that they are prepared to design and build the BalloonSat Module in time before Flight days.

The proposal should be formatted as follows:

- *.pdf format.
- Include Cover page and a Contacts page at the end of abstract.
- Portrait orientation, single spacing, 12-point Times font, left alignment.
- Proposal title should be 60 characters or less, including spaces.
- Number the pages at bottom of each page.
- Maximum of 10 pages excluding Cover Page and Contact Page.

Proposal Components Teams must submit a proposal containing the sections listed below:

1. Abstract
2. Scientific/Engineering Objectives
3. Technical Plan
4. Payload Design & Goal
5. Structure Description
6. Telemetry & Tracking Plan
7. Electronics & Electrical Design
8. Descent Control
9. Team Organization
10. Questionnaire
11. Resource credits

Below are expectations for each section, which can be used as an outline for the proposal. Try including all the points which will drag you to making it to the finalists. A more graphical description of the points would be better. An elementary approach is good enough if you strike the main target with minimum points.

1. Abstract

    - Describe the project in less than 120 words

2. Scientific/Engineering Objectives

    - Clearly describe the project objective and how it will be accomplished.
    - Identify the equipments needed.
    - List the project procedures.
    - Determine the type of data expected and how it will be analyzed.
    - Describe how you expect the project to behave during the flight.
        - Quantify and estimate the effect of near space on the project. How is it different from ground tests or in the laboratory?
        - How sensitive does your equipment need to be to measure the effect?
        - Identify criteria for outcome success.
    - Address the purpose, benefits, and practical applications of the experiment.

3. Technical Plan

    - Provide a clear description of the apparatus, equipment, or hardware to be used or built in greater detail than in Section 2.
    - Include at least one figure or schematic diagram of the entire integration of the module with all subsystems.
    - Describe the expected sequence of events (CONOPS) during experiment operation and how they support the project.

4. Payload Design & Goal

    - Payload Design that you plan to experiment and the primary goal of doing that.
    - Short description of the payload model.
    - The interface and command to the payload and its data logging.
    - Explain how useful data will be collected during the flight and the time interval for acquiring data.

5. Structure Description

- Detail design features that will allow the experiment to survive the flight and be usable for another flight.
- Include diagrams and labeling of the structure where you plan to keep the components.
- Plan to simulate the tests of the structure before actually making it practically.
- Include a chart of the equipment, holders, batteries and boxes, showing the mass of each, not to exceed 1000 grams total.

6. Telemetry & Tracking Plan

- Components you plan to use for such long range communication.
- Integration procedure for the components and its working.
- Tracking procedure for the module as it could possibly exceed 50km range.
- Possibility of taking radio license. Is anyone of your team members willing to clear the license exam for this as it would be mandatory

7. Electronics & Electrical Design

- Include a chart illustrating the power requirements for all equipment.
- Show both voltage and current.
- Include the number and type of batteries needed (i. e. AA, CR2, 9v). If possible, use Lithium batteries which weigh less, handle cold better, and have a little higher voltage. Determine the milliamp hour battery capacity needed for four hours of operation.

8. Descent Control

- Material you plan to use and procedure to test the parachutes.
- Color for the parachutes and purpose.
- Design for secondary descent control phase. (Rate of 2-5m/s)

9. Team Organization Experiment design, development, and operations are team efforts at Universities, and the BalloonSat competition also incorporates teamwork. Teams must work together to plan and coordinate work, design experiments, build experimental apparatus, conduct experiments and explain project plans and results. Include the following:

- Describe the plan for accomplishing the work necessary to research and carry out the experiment, and write the final report.
- Describe the variety of skills individual members bring to the team.
- Explain how the team will distribute the work load and responsibilities.

10. Questionnaire (Answer all the questions in 1-2 paragraphs and include in abstract)

I. Why you are interested in the BalloonSat Competition what benefit will you get from it?

II. Give your team background that you have formed and how it can contribute to a multi-disciplinary research competition like this?

III. What are the primary aspects of mission design your team is planning for and how is innovation or novelty coming into the fore?

IV. Include any relevant technical experience like softwares, fabrication, design etc. you have proficiency in?

V. What progress have you made till now and what is plan of action for the entire competition phase?

VI. How do you plan to cover your monetary needs that will be required for the project competition? Will your college support?

VII. Please provide in brief about any additional information for consideration of your project to the next level.

11. Resource Credits

- List all referenced books, periodicals, and web sites.

Proposal Submission

Fill in the form of "Intent for Participation" @ https://docs.google.com/a/antarikshalabs.in/forms/d/100I4eziPmJyEDCPgNIA3R795ZnrS1U6u6yPpQEjAYys/viewform and we'll keep you updated with new information.

Submit the proposal via email to: balloonsat@antarikshalabs.in

E-Mail Subject: Submissions.<Team Name>.<College Name>
Attachment Name: Abstract.<Team Name>.<College Name>

In the case of enquiry keep subject as : Enquiry.<Team Name>.<College Name>

Team composition

Students currently pursuing their undergraduate degree programs are eligible to participate in the event. A joint Students team from two or three different colleges is allowed upon mutual agreement.

A team should comprise of minimum 4 and maximum 10 students.

It is recommended that students form a team with mix of each departments related as this is complete multi-disciplinary project.

Departments in this project mainly include Payload Unit, On Board Computer & Software Development, Telemetry & GPS Tracking, Command & Data Handling, Ground Station Control, Housekeeping & Descent Control, Power Unit & Circuitry, Structure & Payload Health Unit and Finance/Management. So select students accordingly from concerned college departments to form these.

A Faculty Advisor is needed in the tam whose role is to set an co-ordination aspect in the team, team logistics, arranging labs for experiment and resources, management etc.

A Team Mentor will be assigned to every finalist who would solve your technical problems and other co-ordination related things for the event. The Team mentors would be professionals, scientists and experts from various recognized organizations who will give you enough knowledge for the level of competition and technical solutions.

Agenda

Qualifying Abstract Submission	December 1st, 2013
Preliminary Design Review	February 2nd, 2014
Critical Design Review	May 4th, 2014
Tests: 1 week before Launch dates	
Launch & Post Flight Review	June-July 2014

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References:

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