W6YRA High Altitude Balloon
HA^{2}RRIER

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Contents

1.0 Overview

This document outlines the development and execution of a high altitude balloon (HAB) mission operated by W6YRA at UCLA.

> **Mission Statement**
> To provide students with hands-on experience in software and hardware development, to promote amateur radio, and to provide testing capabilities for other on-campus aerospace-related student organizations.

To fulfill the goals of the project W6YRA will design a repeatable helium-based ballooning system capable of lifting 4kg of payload to a minimum altitude of 20km (nominal altitude of 28km) and returning it safely to earth while maintaining safety and complying with all federal, state, local, and university requirements governing such a mission.

1.1 Naming

Because W6YRA HAB and similar names don't roll off the tongue, we're looking into other names. Leading right now is HA^{2}RRIER. Harriers are part of a family of birds, and the name Harrier, specifically has the HA together for High Altitude in an acronym (or backronym). The acronym currently would be High Altitude Amateur Radio RI Educational Research. RI still needs to be replaced; the name is still a work in progress. Older ideas for names include:

- KOCHAB - A name for Beta Ursae Minoris, and has "HAB"
- HAWK - A group of birds, and has "HA"
- Any variations of names that have some combination of HA or HAB or HA.B. I did searches for `grep -i 'ha.b' /usr/share/dict/american-english`.

2.0 Requirements

2.1 Code of Federal Regulations

High Altitude Balloons fall under the Code of Federal Regulations (CFR): Title 14: *Aeronautics and Space*, Part 101 *Moored Balloons, Kites, Amateur Rockets and Unmanned Free Balloons*. Specifically, this project qualifies as an *Unmanned Free Balloon* by §101.1.4. The following requirements are placed on the mission by that designation:

Design

- The HAB must be equipped with at least two independent flight termination systems (FTS)[1]
- The HAB must be equipped with radar reflection in the 200-2700MHz range

Operation

- The HAB may not be operated within 2000ft (610m) AGL (above ground level) in the lateral boundaries of class B, C, D, or E airspace
- The HAB may not be operated if cloud cover obscures more than 1/2 of the sky
- The HAB may not be operated if horizontal visibility is less than 5mi (8.1km)
- The HAB may not be operated during the first 1000ft (305m) over a congested area of a city
- The HAB may not be operated at night without proper warning lights
- Suspended devices longer than 50ft (15m) must be marked with conspicuous colors or streamers
- The position of the HAB shall be recorded every two hours during flight
- Notification must be given to the nearest FAA (Federal Aviation Administration) ATC (Air Traffic Controller) facility with all pertinent information:
  - 6-24 hours before a flight
  - Immediately after launch
  - Upon request during flight
  - If the position cannot be logged for two hours
  - One hour before descent
  - Upon conclusion of the operation

2.2 Payload

Payload requirements stem from the intended purpose of the balloon and are created internally.

- The payload shall mass no more than 6kg in total (including all FTS and PRS)
- The payload shall be attached at intervals along a nylon cord rated for at least 500lbs (225kg)

[1] Use of a latex balloon counts as one of two FTS

- The PRS shall report position data at least every minute
- PRS shall be completely independent from any other system or payload, both physically and electrically
- FTS shall be completely independent from any other system or payload, both physically and electrically
- PRS and FTS shall mass no more than 2kg
- The payload shall have a parachute capable of slowing decent to a safe velocity ($< 16 f/s$?)
- All payloads shall be securely attached and self-contained such that no objects shall fall uncontrolled from the HAB
- The HAB shall be marked with contact information for recovery

3.0 Design

3.1 Payloads

3.1.1 Test Flight

An initial test flight will likely be run using a system rated for 2kg with only the W6YRA payload. This system would have the standard sized parachute, radar reflector, FTS, and PRS to simulate a final flight while reducing the loss of payload risks.

3.1.2 Payload Flight

In order to provide space to as many aerospace-concerned student organizations as possible, the following payload mass allotments have been created:

- W6YRA: 2kg
- Electron Losses and Fields Investigation (ELFIN)[1]: 1.5kg
- American Institute for Aeronautics and Astronautics (AIAA)[2]: 2kg
  - UCLA Rocket Project (URP): 1kg
  - Design Build Fly (DBF): 1kg
- Arko Robotics[3]: .5kg

Due to limitations in the capability of the balloon and recovery systems, any payload over these masses shall be rejected.

3.2 Balloon

Possible manufacturers include:

- Hwoyee (Arko)
- Totex from Kaymont (EOSS)[4]

3.3 Position Reporting System

Possible PRS options include commercial single board systems (Big Red Bee 2 meter), homebrew single board systems (Radio module, GPS module, and some microcontroller/processor), homebrew multi-component systems (similar to the homebrew but using a dedicated handheld radio for increased power), or some combination of those.

[1] Remaining overall payload mass go first to ELFIN

[2] Remaining payload mass form DBF and URP may be used by other AIAA group up to the 2kg limit

[3] Or other outside student groups; Arko Robotics is specified here due to W6YRA's involvement in telemetry downlinking on a HAB mission run by Arko Robotics

[4] http://www.eoss.org/pubs/faqloon.htm

3.4 Flight Termination System

Burst of a latex balloon serves as one method of terminating a flight. The other method will be a payload cutdown either by a pyrotechnic propelled blade or a burn wire to burn through the main line.

3.5 Recovery

Recovery will be handled by a parachute tied above all payloads except FTS. The parachute will measure roughly 9-10ft (2.5-3m). Additionally, the parachute will be secured to a spreader ring to help it deploy properly. The parachute will be left open, tied to the line, without any method of storing or compressing it. To avoid fouling lines, the parachute may be secured to the main line both at the spreader ring and at the top of the parachute.

4.0 Funding

4.1 Projected Cost

Flight Hardware

Flight hardware includes all components necessary for basic balloon flight. All devices in this section are legally required for an HAB and cannot be descoped. The subtotal for this section represents the base cost of the mission.

Balloon	$100
GPS/Tx	$300
Battery	$50
Foam	$50
PVC	$50
Cord	$40
Helium	$100
Chute	$100
Radar Reflector	$75
Cord Cutter	$100
15% Margin	$130
Subtotal	$1110

Payload

The payload section includes costs for a data collection based payload. It centers around a camera module to obtain pictures at high altitudes and an Arduino-based data collection module with sensors for temperature, pressure, and acceleration. Other possible sensors include: humidity, gyroscopes, and high-g accelerometers for burst data. Data will be recorded onboard and read upon recovery. Costs in this section would augment the basic mission allowing for more student engagement and interesting data collection, however, these costs could ultimately be descoped.

Camera	$120
Foam-Core	$50
Arduino	$50
Temperature Sensor	$5
Pressure Sensor	$20
Accelerometers	$20
15% Margin	$40
Subtotal	$305
Total	**$1415**

Reward

If the project receives enough funding, a reward may be offered for recovery of the payload outside nominal operation (loss of position information during flight).

4.2 Sources of Funding

Funding is the major concern at the moment. W6YRA has been registered under UCLA's latest club system to allow for grant proposals. Any information about other possible funding sources is appreciated.

5.0 Resources

- Canon Hack Development Kit http://chdk.wikia.com/wiki/CHDK
- Sparkfun on CHDK https://www.sparkfun.com/tutorials/186
- Sparkfun overall HAB (Nate's) https://www.sparkfun.com/tutorials/180
- Sparkfun overall HAB (Aaron's) https://www.sparkfun.com/news/906
- Edge of Space Sciences (Almost 200 flights worth of tutorials, designs, missions, pictures, schematics, etc.) http://www.eoss.org/
- HABEX, a group launch in the Imperial Valley http://wiki.032.la/HABEX2