Extended flight time of latex balloons through the use of a buoyancy control system

Jeffrey F. Dailey
Taylor University
jfdailey@taylor.edu
236 W Reade Avenue, Upland IN 46989, 765-998-4365

ABSTRACT

For over ten years Taylor University has operated a High Altitude Research Platform (HARP). This program includes building instruments and control systems to be flown in the near-space environment. We have designed and built an efficient, and durable buoyancy control system that increases the functionality of high altitude balloons giving us the capability of controlling the ascend, descend, hold altitude as well as avoiding the post-burst chaos and extending the flight time of latex balloons.

KEYWORDS: HARP**,** Efficient, Buoyancy, Post-burst chaos, Latex balloon

INTRODUCTION

For more than ten years Taylor University has been developing instrumentation to be flown on latex balloons with over 260 flights. Throughout, we have been developing the payload to withstand the post-burst chaos. With the need to increase the flight time and to maintain a constant altitude, we began research into the design of a buoyancy control system to allow long flight durations, constant altitude, controlled descend and avoid the post-burst chaos.

BACKGROUND

To date there are three types of balloons that are used to maintain a constant altitude 1) zero pressure, which are large and partly filled at release 2) super pressure, which are filled to extend fully the envelope at release 3) tetroon, which are small, super pressure balloons that are tetrahedral in shape. All of these require the size of the envelope to vary based on the payload weight and the desired altitude.

NEW BUOYANCY CONTROL SYSTEM

The Research Department at Taylor University is working on developing a valve control unit to be usable on different size balloons ranging from 200 – 3000gm which is shown in Figure 1. These are micro controller based units with onboard GPS receiver and dual servo valve system. A user interface setup menu allows the user to set 1)the float altitude, 2)rate of ascend/descend, 3)float time, and 4)abort time.

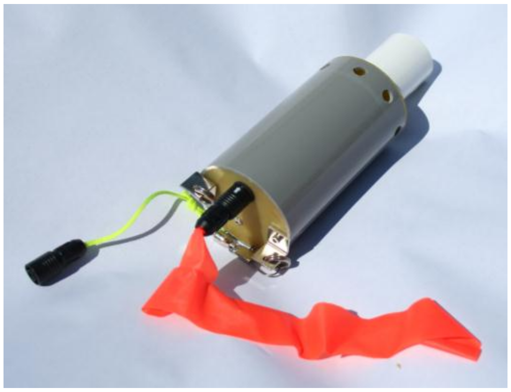

Figure 1 – 200 to 1500gm valve assemble

EXTERNAL EFFECTS ON BUOYANCY

Balloons fly in a radiant energy environment. The internal pressure and gas volume is sensitive to the changes in radiant energy around it. The different external variables that can affect the balloons are 1) solar radiation direct from the Sun, 2) Cloud Albedo, 3)Earth Albedo, 4) Earth IR, 5) Cloud IR, 6) Sky IR and some of the outputs are the outer skin and inner skin.

All of these affects influence the control of the balloons altitude as shown in Figure 2. The micro controller takes these variables and the user inputs to control the valve servos to maintain a constant altitude during the “float phase” of the flight. At the flight termination time, the value servos are opened and rate of descent checked against the user defined rate to maintain a constant descent. See Figure 3 for a recent test flight with a controlled altitude and descent profile.

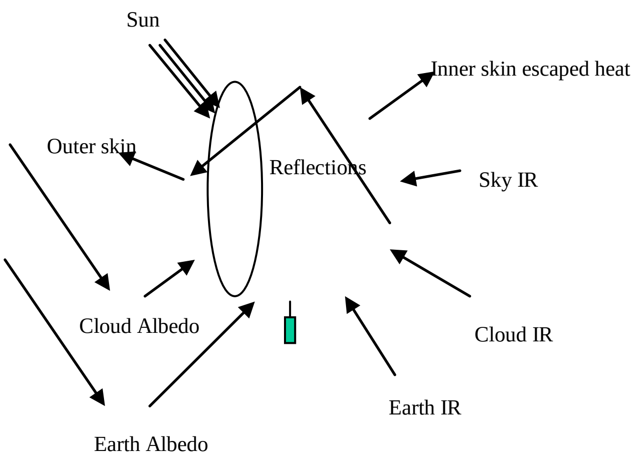

Figure 2 - Forces Affecting Balloon Buoyancy

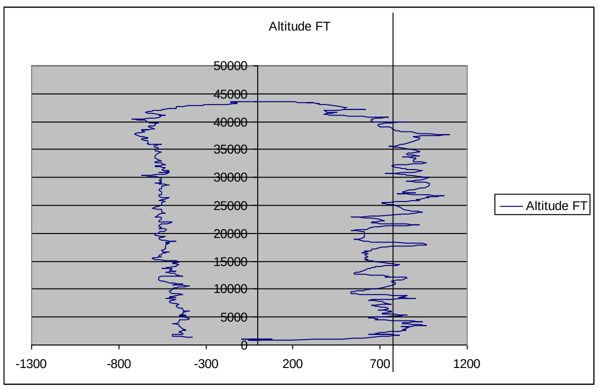

Figure 3 - 600gm Buoyancy Profile

APPLICATIONS

This technology opens up new capabilities for latex balloon envelopes in allowing for longer then two hour flights and removing the post-burst chaos for a more useful controlled descend profile. With float capability, the payload can be held at a desired altitude for a predetermined time 1) allows for acquiring a large amount of data at the desired altitude 2) and not just as the payload passes through it 3) this also allows the instrument to drift with the wind across a larger geographic area, at a altitude where the wind speed is at low point or direction has changed. By adding the ballast tank it is possible to increase the altitude for profiling at different levels and ascend/descend rates.

All of the following instruments could benefit from the use of the **BUOYANCY CONTROL SYSTEM** because it allows them to maintain altitude and helps sustain long duration flight times **1) Optical Spectrometer -** is a solar occultation instrument that will measure the trace constituents of the atmosphere by measuring the absorption of sunlight. 2) **Very Low Frequency (VLF) Receiver -** allows the instrument to be at a fixed altitude as a thunderstorm passes below. 3) **Electric Field Probe** - can be used for clear weather or thunderstorm research. Allows the instrument to be above, below, or within the thunderstorm. 4) **Ozone Instrument -** by keeping the balloon at fixed altitude will allow the instrument to drift with the wind comparing the level across a larger geographic area. 5) **ION Probe** - by keeping the Ion Probe at fixed altitude in the lower atmosphere for cloud microphysics. 6) **Dropsondes** - are instrument packages that can be released from a fixed altitude above the storm as it passes below the balloon.

FUTURE WORK

- Refining the control algorithm for different sized balloon envelopes and payload weights.
- Working on flight scenarios and profiles to increase the capabilities of the system.

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