Superpressure Balloon Ideas

Bristol SEDS has been very successful in developing Superpressure balloons [1]. These balloons fly in the lower stratosphere for several months and cover thousands of kilometres in distance. We hold the record for the 2nd longest amateur balloon flight (55 days and counting!)[2]

Google Project Loon [3] is also using Superpressure balloons, and you will find their videos to be a useful source of ideas. However, please note that Bristol SEDS balloons are much smaller, and hence are currently limited in the payload mass they can carry:

- 30 grams for long duration (1 month+)
- 75 grams for short duration (4 – 7 days)

Your payload proposals should include a rough mass budget that meets these restrictions. (If your payload does not include a GPS tracker, then you should include 15 grams in your budget for this).
ALTERNATIVELY, if your payload weighs more than 75 grams, you could submit a proposal for launching a meteorological balloon, which will land after about 3 hours in the air. There's more information about launching meteorological balloons in [4].

Proposals could also include some technical work, such as a list of parts, circuit diagram, cost budget etc.

[1] https://en.wikipedia.org/wiki/Superpressure_balloon
[2] http://www.bristol-seds.co.uk/hab/flight/2016/08/17/ubseds18.html
[3] https://www.solveforx.com/loon/
[4] https://ukhas.org.uk/general:beginners_guide_to_high_altitude_ballooning

Idea #1: Alternative sources of power in the stratosphere

Currently Bristol SEDS uses solar panels to power payloads. These make up a significant proportion of the payload's mass, and only work during the daytime.

We could analyse and design an alternative power source, such as:

- A longwave IR collector, that exploits the temperature difference between the warm earth and the coldness of space.
- A system that recovers energy from Atmospheric waves [1].
- Very high efficiency panels (> 0.8W/gram in full sun) that we can buy for a reasonable cost.
- A system for rotating panels to face the sun, rather than the current design of pointing them upwards.

A further challenge will be converting this power to a usable 4 to 5 Volt supply.

[1] https://en.wikipedia.org/wiki/Atmospheric_wave

Idea #2: Power storage in the stratosphere.

During the stratospheric night the payload temperature is typically -60 degrees Celsius. We have not yet found a rechargeable battery that works reliably at this temperature.

We could analyse and design an alternative power storage system:

- A battery chemistry capable of functioning at -60 that we can buy at a reasonable price (such as Lithium-Sulphur).
- A mechanical power storage system, such as a flywheel or gravity potential system.
- A system that stores thermal energy during the day and uses it to keep the battery warm at night.

Idea #3: Returning a balloon to the UK

All of our Superpressure balloons thus far have been lost and never recovered. However, as our flights grow longer, we expect one will eventually pass above the UK again. If the balloon could somehow be remotely deflated and sink to the ground, then we could be the first amateurs to recover a round-the-world balloon flight.

We could:

- Design a system for remotely deflating the balloon.
- Consider the logistics of picking up a balloon from anywhere in the UK at any time of day.

- Model how often a balloon passes over the UK, using historical wind data.
- Create a system that calculates the optimum time to deflate the balloon, in order to give a convenient landing location. This would use live wind data.

We may need to use wind datasets (such as HRES[1] and the GFS[2]) and the tools for working with them (such as HYSPLIT[3] and tawhiri[4]).

[1]: http://www.ecmwf.int/en/forecasts/datasets/set-i
[2]: https://www.ncdc.noaa.gov/data-access/model-data/model-datasets/global-forcast-system-gfs
[3]: http://ready.arl.noaa.gov/HYSPLIT.php
[4]: https://github.com/cuspaceflight/tawhiri

Idea #4: Faster radio transmissions

In order to return more data from the balloon, we need to increase the speed and range of the radios we use. We are currently limited to 300 bits per second at 400km range and 8 kbits per second at 80km range.

This limits the useful data that can be received from the balloon. In particular images can only be received for a short time when the balloon is near receiving stations.

We are planning to implement a system using Binary Phase Shift Keying and Forward Error Correction (BPSK/FEC) with the aim of delivering 10 kbits per second at 400km range and 100kbits per second at 80km range.

We could:

- Test this system around Bristol, with the aim of improving the performance.
- Conduct test flights to test higher data rates.
- Design a low-cost receiving station for this system.
- Raise money to manufacture receiving stations for this system, and distribute them around the world so that we can receive data from the balloon outside the UK.

Idea #5: Long range radio transmissions

Our current balloon tracker electronics uses 144MHz and 434MHz radios. The range of these radios is limited by the distance the balloon can see to the horizon – typically 400km. Hence the balloon cannot be tracked over the oceans and remote areas such as Siberia.

There are other frequencies (such as HF) and weak-signal modes where the radio signal can propagate much further, even across the whole globe. Possible modes to consider are WSPR, JT9/65 or using Iridium Satellite Communications.

We could design a transmitter for one or more of these modes, and then fly it on a balloon.

Idea #6: Uses for balloon data

The balloon gathers information as it flies, both from the temperature sensor it carries, and implicitly from the GPS data.

We could:

- Include sensors to measure pollutants in the atmosphere.
- Confirm the balloon has zero airspeed, by using a microphone.
- Contribute the GPS data to wind models, which would improve weather forecasts for everyone.

It may be worth contacting university academics who have some research interest in atmospheric chemistry

Idea #7: Visualisations of Balloons and Receivers

Our website has a page for each balloon flight. On that page there's a map and statistics about the flight (duration, distance), and a list of the amateur radio stations who received it [1]

This information is automatically generated by a tool called "magic ring binder" [2], which is currently written in the Python programming language.

We could improve our website with visualisations of the balloon flight! We could include:

- Temperature and weather data along the route
- A map of the paths taken by the radio signals from the balloon to the receiver.

[1] http://www.bristol-seds.co.uk/hab/flight/2016/04/30/ubseds15.html#map
[2] https://github.com/bristol-seds/bristol-seds.github.io/tree/master/_tools/magic-ring-binder

Idea #8: Improve Balloon Manufacturing

Much of our ballooning success has been down to our custom balloon design, which is superior to anything that can be bought on the open market. However, it is difficult to manufacture and the balloon size is limited.

We currently manufacture balloons by heat sealing polyethene-polyethene by hand, in 20cm segments. The balloon has about 10m of seal length, so manufacturing takes a long time (about 8 hours). This could be improved by building a larger heat-sealer.

The largest balloon we have produced so far is 1.9m in diameter. This limits the mass of the payload to the limits described above. If we could find a larger space to manufacture the balloons in, then we could fly heavier payloads. The space needs to be available for a long period (about a week) to allow us to manufacture the balloon, pressurise it, and then launch. The space must be accessible between 03:00 and 06:00 on a Saturday and Sunday for launch operations.

Idea #8: Improved camera system

Last year Bristol SEDS developed ‘pico-pi’. It returned the first pictures of an amateur Superpressure balloon at float [1].

However, it only returned about 10 high-quality images, because of the short range of the radio, and the limited power to run the camera. The flight only lasted 4 days, because it was a high payload mass (75 grams) on a small balloon.

To improve this system so it returns more or higher quality images, we should work in Ideas #1, #4, #5 and #8, as well as re-designing the payload to achieve a lower mass.

[1]: http://www.bristol-seds.co.uk/hab/flight/2016/08/29/ubseds20.html

Idea #9: DSLR Camera System

Using a DSLR Camera would allow us to capture images of a higher quality than those from the pinhole camera suggested for Idea #8. However, we would not be able to transfer back the images live because of the large file size. Instead we could return the balloon to the UK and read off the images then.

To pull this off we would need major progress on Ideas #3 and #9, as well as funding to buy several cameras.

With some work on stabilisation, a balloon would be an excellent platform for astrophotography [1]. In particular, the cold temperatures (-40 degC) [2] and excellent seeing conditions would be an advantage. However, doing this would also require major progress on Ideas #1 or #2.

[1] https://sites.physics.utoronto.ca/bit
[2] http://petapixel.com/2016/10/11/cooled-nikon-d5500a-chills-sensor-clearer-star-photos/