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| Stratospheric Data Collection via Telemetry Using High-Altitude Weather Balloon |

Interim Report

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# Abstract

Weather balloons are an invaluable tool used professionally by meteorology organisations for collecting various types of atmospheric data used in forecasting the weather. This includes collecting things such as atmospheric pressure, humidity, and temperature. Outside of the professional sector they are highly used by radio amateurs to gather sensor data and photos and videos of the Earth’s curvature. The types of sensor data commonly collected by amateurs are from a 3-axis accelerometer, 3-axis gyroscope, 3-axis magnetometer, relative humidity, altitude, temperature, pressure, ambient light, and ultraviolet light. These are then transmitted to ground via the onboard telemetry via the 70cm 434MHz HAM band to a computer connected to a radio receiver, DVB-T dongle, Funcube+ dongle, or airspy which is tuned to 434Mhz. The main tracking computer is usually run inside a chase car with a magnetically mounted 70cm band antenna. The GPS location of the balloon is broadcasted the same way as the sensor data with the coordinates acquired from an onboard GPS module connected to low orbit satellites. A service called habhub is used by the majority to allow anyone around the world to track the balloon. This has the advantage of filling in any signal loss you may encounter since someone else is relaying the coordinates to the server for you. Balloons of various sizes, commonly between 300-600g for first time launchers ascend until a point (usually 60,000-120,000ft depending on the balloon size, with larger more expensive ones achieving higher altitudes) where the air pressure is so low (about 0.1 atmospheres) which causes the balloon to expand until rupturing. At this point the payload containing the electronics descend with a legally required parachute somewhere near a previously software predicted landing location. This is commonly between 2-3 hours away from the launch location. Lots of preparation is done to ensure the prediction is not in the ocean. Though prediction algorithms aren’t perfect, and the weather has tendency to change unpredictably so the landing location prediction needs constant rerunning to ensure the most updated location is known.

Ukhas.org (UK high altitude society) is the single most abundant and reliable source of high-altitude ballooning on the internet with veteran members creating articles which instruct others how to launch a balloon of their own. These members have been approached by organisations such as the BBC to fabricate and launch balloons for TV and have helped myself in this project with direct correspondence or through their articles. Credit will be paid to them where appropriate in interim or dissertation. Without their contributions this project would have not been possible to carryout due to its complexity.

# Introduction

# Design Constraints

## Altitude

The burst altitude is dependent on various factors such as the size of the balloon, payload weight, and rate of ascent. Common 600g Totex balloons have a burst altitude of between 75,000 - 90,000ft whereas larger and more expensive balloons (800g-4000g) have a larger gas capacity and extended amount of stretch than smaller ones (100-600g). So, they have a longer time of ascent, hence altitudes of beyond 90,000ft can be achieved (Kaymont.com, 2020). For this project a 600g will be used as it is the most commonly used latex balloon for first time launchers and can be purchased from Steve Randall’s website; randomengineering.co.uk for

## Launch

In the UK, permission must be obtained prior to launch from the Civil Aviation Authority (CAA) before any weather balloons can be launched. An OS map pinpointing the planned launch location must be sent before permission is granted. If valid, permission and a NOTAM (notice to airmen) will be issued. Due to unpredictable weather a window of different launch dates should be requested. 28 days prior notice must be given before planned launch date (Stirk, 2012).

## Location

## Software Defined Radio

Software defined radio is an inexpensive alternative to using an expensive but also more sensitive radio such as the most commonly used Yaesu 817. SDR dongles utilise the Realtek RTL2832U chipset and computer’s soundcard to decode radio signals. However, SDR dongles are repeatedly discouraged for tracking actual balloon flights due to their reduced sensitivity when compared to a proper radio. Although, this argument is conflicted by different people and a compromise has to be taken.

## Tracking

After launching of the balloon, a chase car with a magnetically roof mounted 70cm band antenna connected with a length of SMA terminated RG174 cable is fed to and usb dvb-t dongle connected to a computer running sdrsharp software tuned to 434.425MHz, the same as the payload transmitting frequency. The received RTTY tones are then sent to dl-fldigi software via a virtual audio cable where the tones are decoded in sentences containing the GPS coordinates of the balloon’s current position. This GPS information is then relayed to habhub to allow worldwide tracking of the balloon (Stirk, 2012).

## Flight Computer

Original plans were to use the raspberry pi as per mentioned by Heather Lomond Ph.D, a member of TDARS amateur radio group I attended as per suggestion of Mohammad Sayed. The raspberry pi allows the use of the pi camera which could have programmed to take photos every x seconds. Heather has launched two weather balloons before and shared her story of how she achieved it. She mentioned she used the pi-in-the-sky flight tracker developed by Dave Akerman. This is a tracker that is pre-made by one of the expert HAB members to slot on the top of raspberry pi. However, due to price of £144, an ambitious decision to develop my own flight tracker was made.

## GPS

The GPS module chosen for this project is the uBlox Max-M8Q. This is the most commonly used GPS chip used by the HAB community because it continues to operate up to 50,000 meters when in flight mode. Not all GPS modules continue to work at this altitude and result in monotonic values. This ensures the balloon’s location doesn’t go silent when the balloon goes beyond the operating altitude (uBLOX MAX-M8Q Breakout for Active Antennas, 2016).

## Balloon

A 600g Totex balloon from randomengineering.co.uk is going to be used to carry a payload of 500-900g

## Size

## Payload

## Gas

## Transmitter

## Parachute

## Power Supply

## Regulations

## CAA Limitations

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## SDR

## Budget

## Sensors

## 9 Axis Sensor

## Talk about the 3 axis acceleraomter, 3 axis gyroscope, and 3 axis magnometer.

## Ambient Light Sensor (GY-302)

## Talk about how the light sensor will be used to record the light level increase/decreate during the flight of the ballon

## UV Light Sensor (GY-8511)

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## Voltage Sensor

## Talk about how the voltage sensor can be used to monitor the battery percentage and so that we can look at how to battery level went down during the flight of the balloon.

## Printed Circuit Board (PCB)

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