Sheep Worrier: A High Altitude Balloon Flight & Recovery System

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- Overview
- Sheep Worrier
- Shepherd
- Sheep Dogs
- Sheep Dog Puppy
- Other Stuff
- On The Road
- Up Up and Away
- There and Back Again

Overview

- Sheep worrier
  - The actual balloon hardware (payload, latex Balloon, parachute).

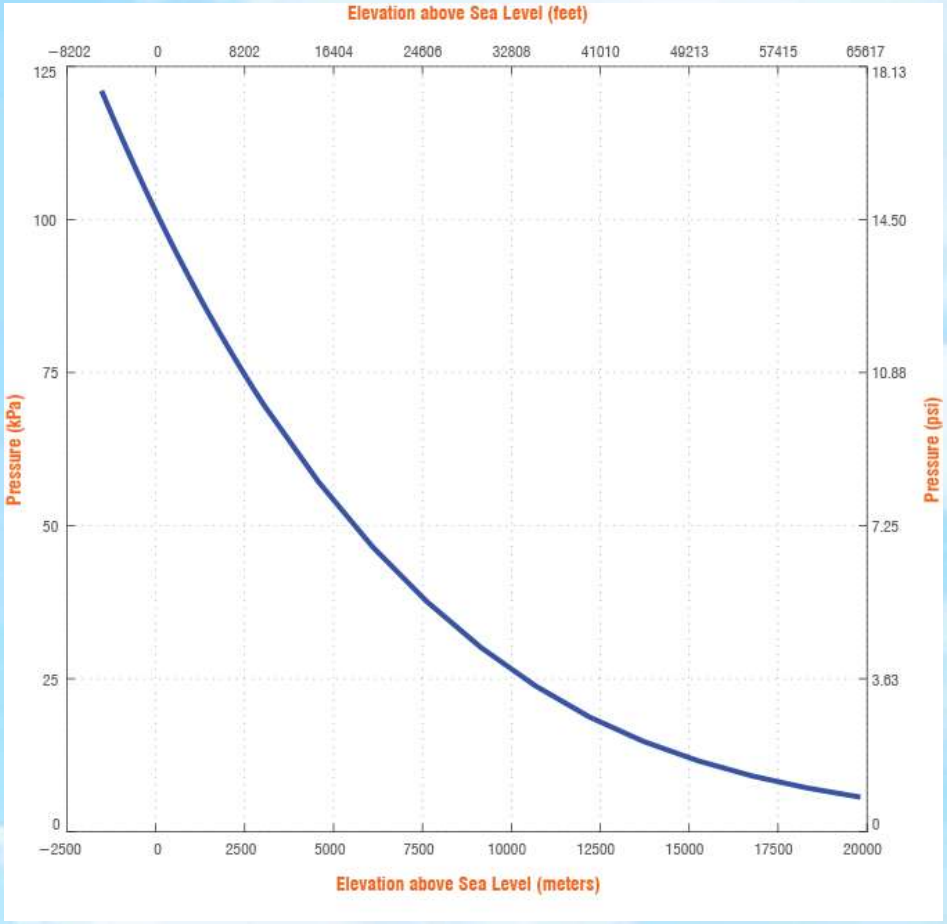
- Sheep Dog
  - The chase car/radio/PC

- Sheep Dog Puppy
  - The tripod based tracker, android tablet, RPI, sensors

- Shepherd
  - Tethered balloon, LoRa to Wifi Gateway

Why? - Edge of Space

- Altitude:
  25Km+
- Temperature:
  -55 Deg.C
- Atm. Pressure:
  close to 0
- Curve of Earth:
  sadly, not quite
- Science
  do something new
- **Because We Can**



Sheep Worrier

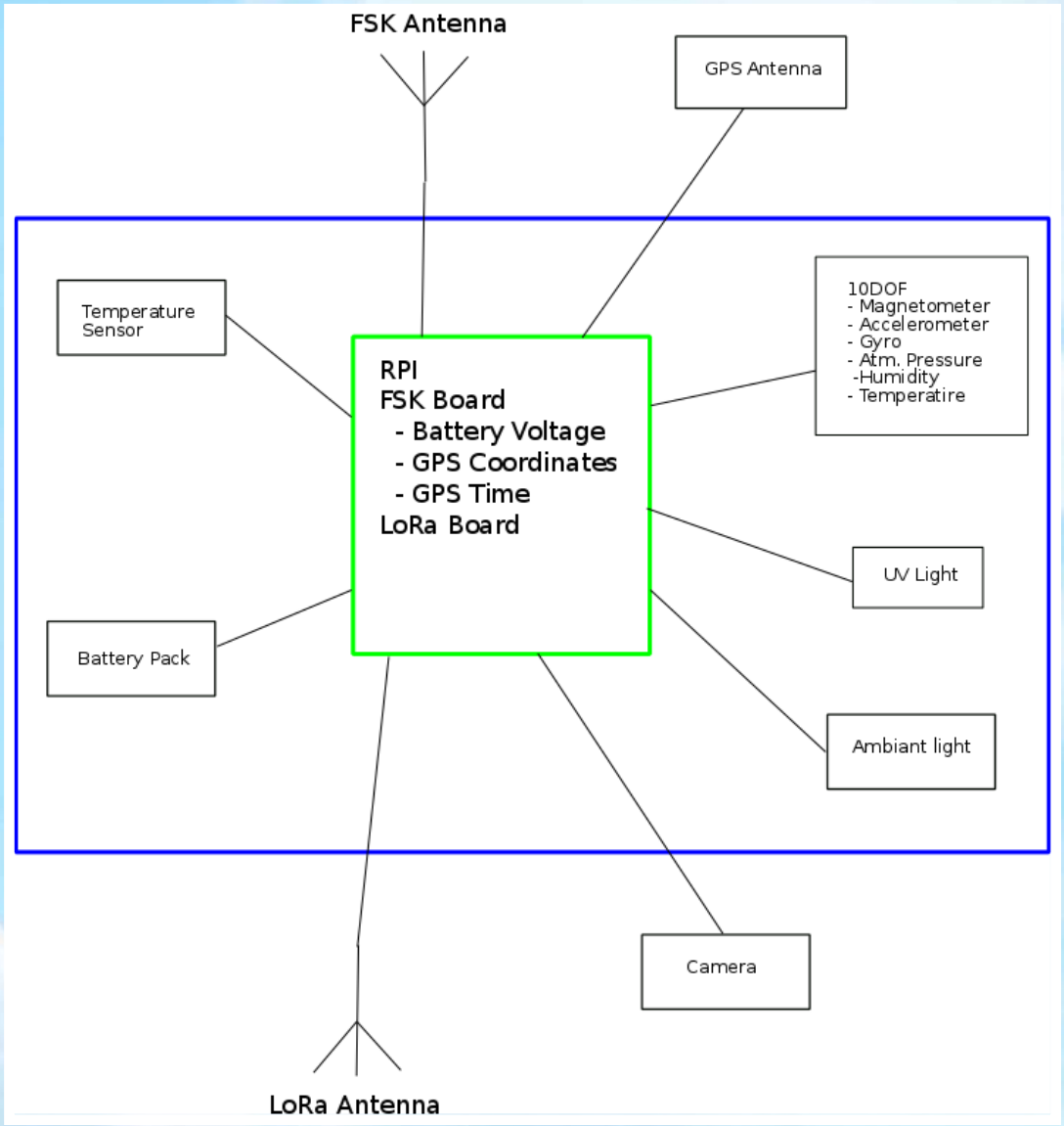
- Raspberry Pi model A
- PITS Tracker Board (GPS, Radios)
- Custom Sensor Hardware
- Thermal Insulation
- Custom software
- Very big Balloon
- Parachute
- … In a Pop Bottle or Two!

The Pepsi Challenge

- 2 pop bottles, heat stretched to overlap
- Tied together internally
- Insolation and Polystyrene

Worrier's Vital Statistics

- Helium filled
- 600g latex ballon
- 1m diam at sea level
- 10m diam when it pops
- Total weight 1.3kg
- 4 AA lithium batteries
- Lots of nylon chord



Who'd have a latex allergy?

- Lots of calculations for ascent rate, descent rate etc!

Fill ‘er up please

- Neck Weight adjustment for ideal lift - Just add water!

BOC
A Member of The Linde Group
Balloon Occasions
Disposable
helium cylinder
Inflates 50 x 9"
latex balloons

Sheep Worrier - Hardware

- 8 MegaPixel RPI camera V2.1
- Large sensor array:
  - 3 axis accelerometer & Gyroscope – MPU9250
  - 3 axis compass – AK8963
  - Atm. pressure, Internal temperature BMP280
  - UV light levels - VEM6070
  - Ambient light levels – BH1750FVL
  - External temperature (thermocouple) – ADS1115
  - GPS (lat., long., altitude, speed etc.) – UBLOX 7
  - Battery voltage and current sensors
- 2 Radios

Sheep Worrier – Radios

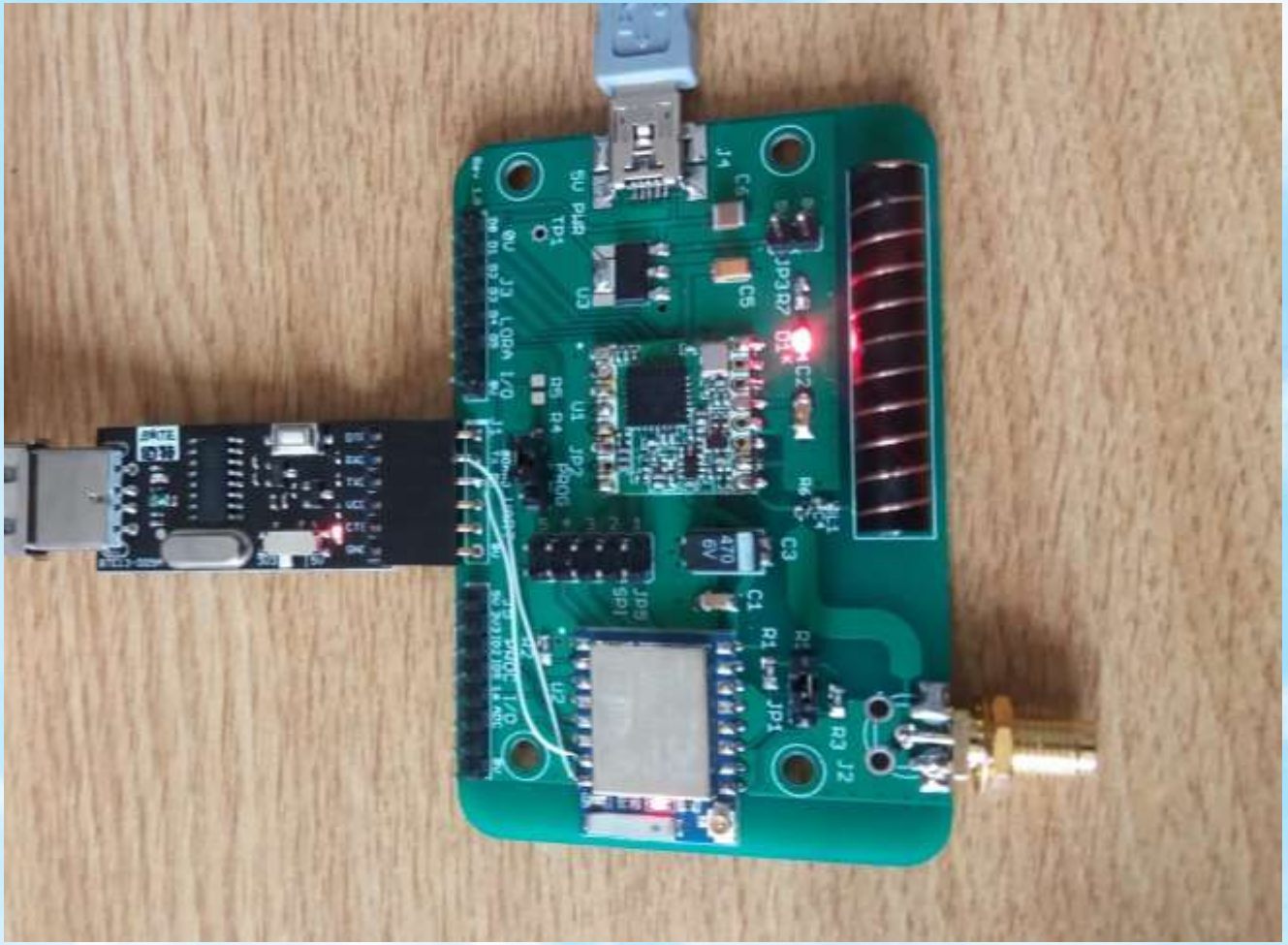
- There are two radios for telemetry
  - FSK RTTY Sentences, 10mW, 434MHz ISM band.
    - 50 Baud, 670Hz separation
  - LoRa Sentences, 10mW, 434MHZ ISM band
    - Proprietary spread spectrum

$$SLUG,16,05:16:00,52.67044,2.44418,00159,
0,0,6,4.1,0.175,14.6,12.5,99660*54A6“

Sheep Worrier – Software

- Pi In The Sky (PITS) – by David Ackerman
  - Multithreaded Application
  - Auto boot
  - Auto restart
- SLUG Custom code
  - Internal GIT repo
  - Driver library for the sensors
  - Custom LoRa Code
  - Custom camera drivers

Shepherd



Shepherd - internals

- A LoRa 434MHz spread spectrum radio
- An ESP8266-07 2.4GHz Wifi enabled micro
- Programmed via the Arduino IDE

- Receives signals from the landed (crashed) balloon
- Relays them via a set of web pages to the ground based Humans

SLUG H/W design done in Eagle CAD & Now KiCAD

Balloon Tracking
192.168.1.10/balloon.html
Apps Electronics, Cars, habhub tracker (ISP X7n ADSL Ro Arduino - String Source Code For Heather Email Wiki Other bookmarks

Balloon Tracking

Last received message:

$$SLUG,103,20:39:02,52.55668,-2.66481,00156,0,0,12,28.9,0.0,0.000*B20F

Time: 20:39:2

Latitude: 52.556680
Longitude: -2.664810
Altitude: 156.0

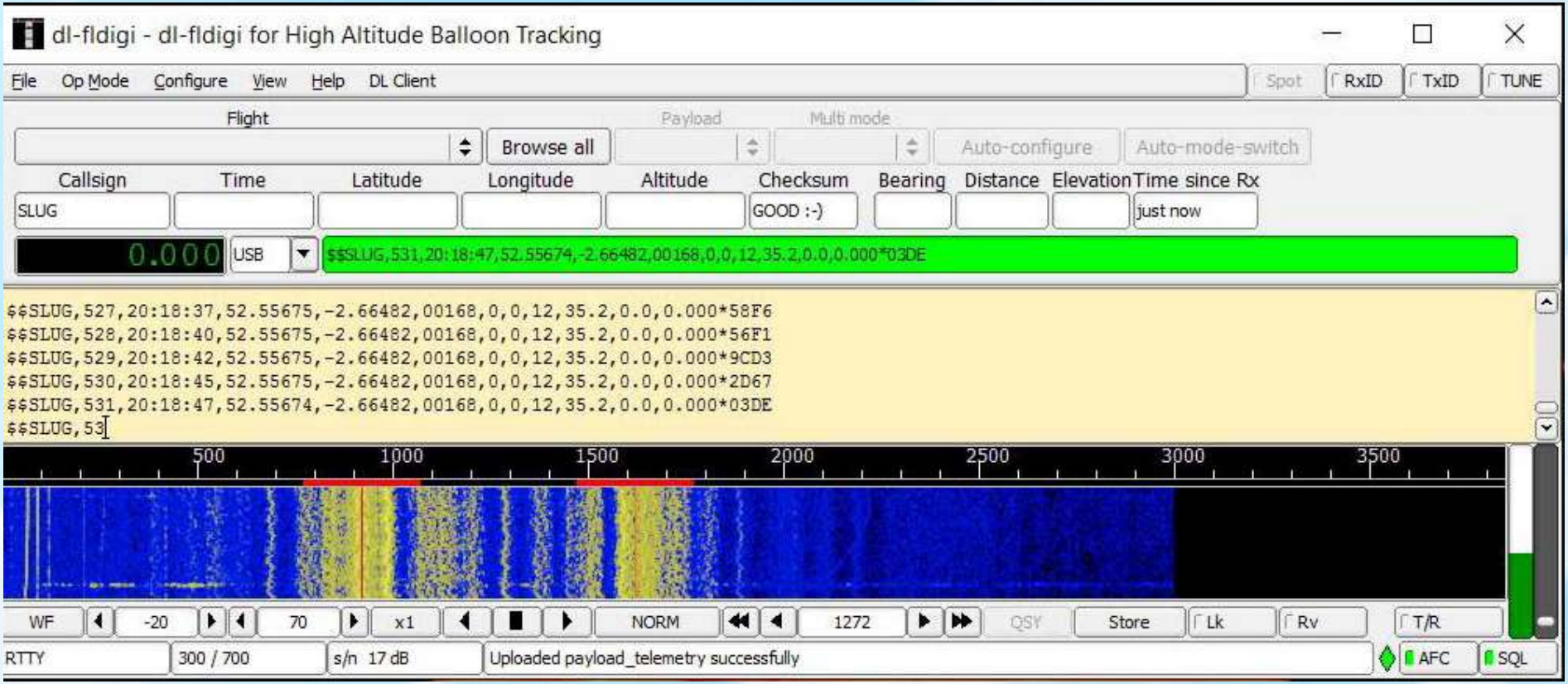
GPS Temperature: 28.90

Sheep Dog Mother

- Chasing the balloon is fun!!!

- Yaesu FT857 (Audio/CAT control to PC)
- Roof mounted Super Gainer Vertical
- Android mobile running a hotspot
- PC running Windows 10
- Dl-fldigi FSK decoding
- Puppy antenna as a backup

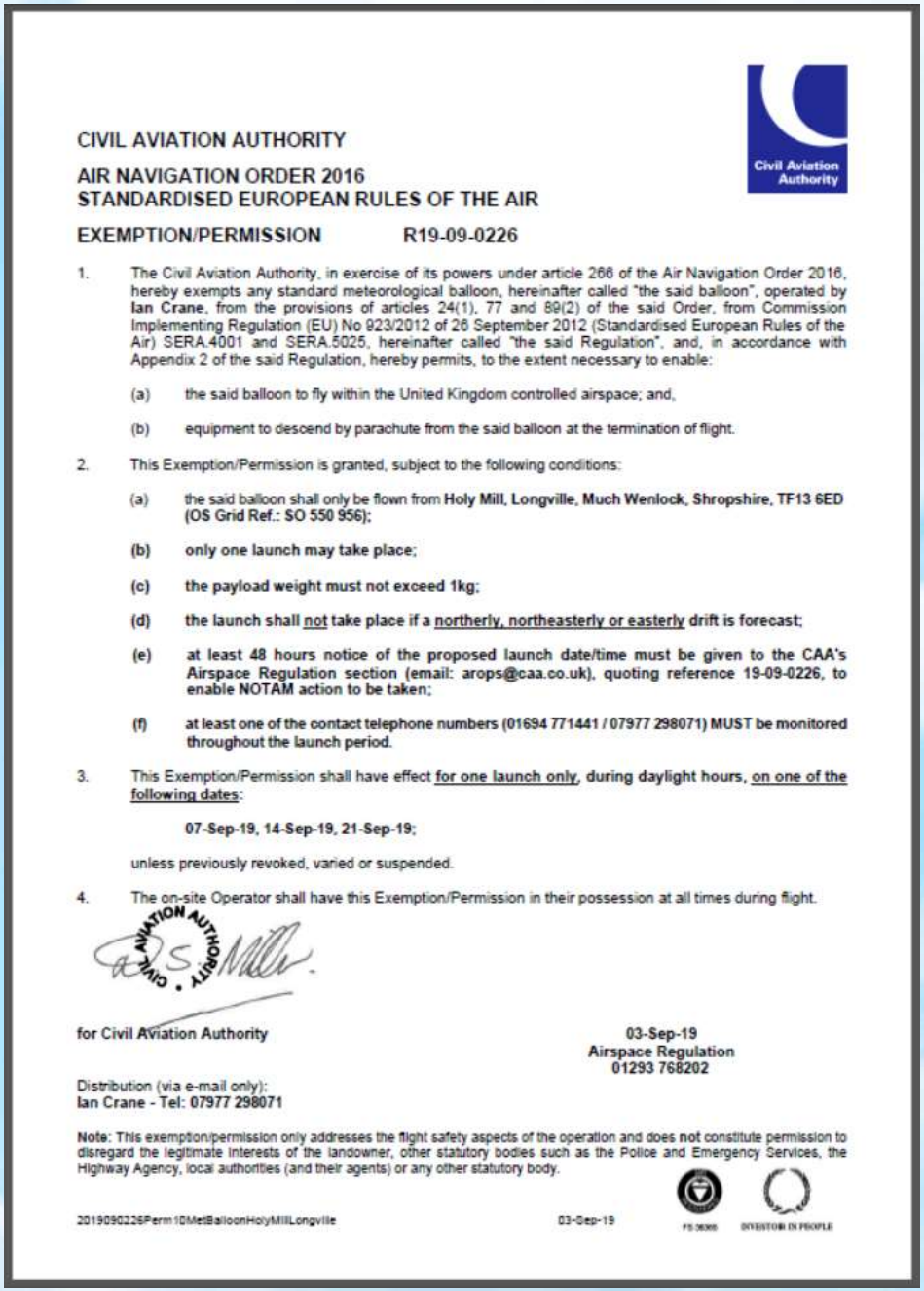
Dl-fldigi in action



Sheep Dogs Phone Home

- https://tracker.habhub.org/

Dog License



CIVIL AVIATION AUTHORITY

AIR NAVIGATION ORDER 2016
STANDARDISED EUROPEAN RULES OF THE AIR

EXEMPTION/PERMISSION R19-09-0226

1. The Civil Aviation Authority, in exercise of its powers under article 266 of the Air Navigation Order 2016, hereby exempts any standard meteorological balloon, hereinafter called "the said balloon", operated by **Ian Crane**, from the provisions of articles 24(1), 77 and 89(2) of the said Order, from Commission Implementing Regulation (EU) No 923/2012 of 26 September 2012 (Standardised European Rules of the Air) SERA.4001 and SERA.5025, hereinafter called "the said Regulation", and, in accordance with Appendix 2 of the said Regulation, hereby permits, to the extent necessary to enable:

   (a) the said balloon to fly within the United Kingdom controlled airspace; and,

   (b) equipment to descend by parachute from the said balloon at the termination of flight.

2. This Exemption/Permission is granted, subject to the following conditions:

   (a) the said balloon shall only be flown from **Holy Mill, Longville, Much Wenlock, Shropshire, TF13 6ED (OS Grid Ref.: SO 550 956);**

   (b) only one launch may take place;

   (c) the payload weight must not exceed 1kg;

   (d) the launch shall not take place if a northerly, northeasterly or easterly drift is forecast;

   (e) at least 48 hours notice of the proposed launch date/time must be given to the CAA's Airspace Regulation section (email: arops@caa.co.uk), quoting reference 19-09-0226, to enable NOTAM action to be taken;

   (f) at least one of the contact telephone numbers (01694 771441 / 07977 298071) MUST be monitored throughout the launch period.

3. This Exemption/Permission shall have effect **for one launch only, during daylight hours, on one of the following dates:**

   07-Sep-19, 14-Sep-19, 21-Sep-19;

   unless previously revoked, varied or suspended.

4. The on-site Operator shall have this Exemption/Permission in their possession at all times during flight.

CIVIL AVIATION AUTHORITY

for Civil Aviation Authority

03-Sep-19
Airspace Regulation
01293 768202

Distribution (via e-mail only):
Ian Crane - Tel: 07977 298071

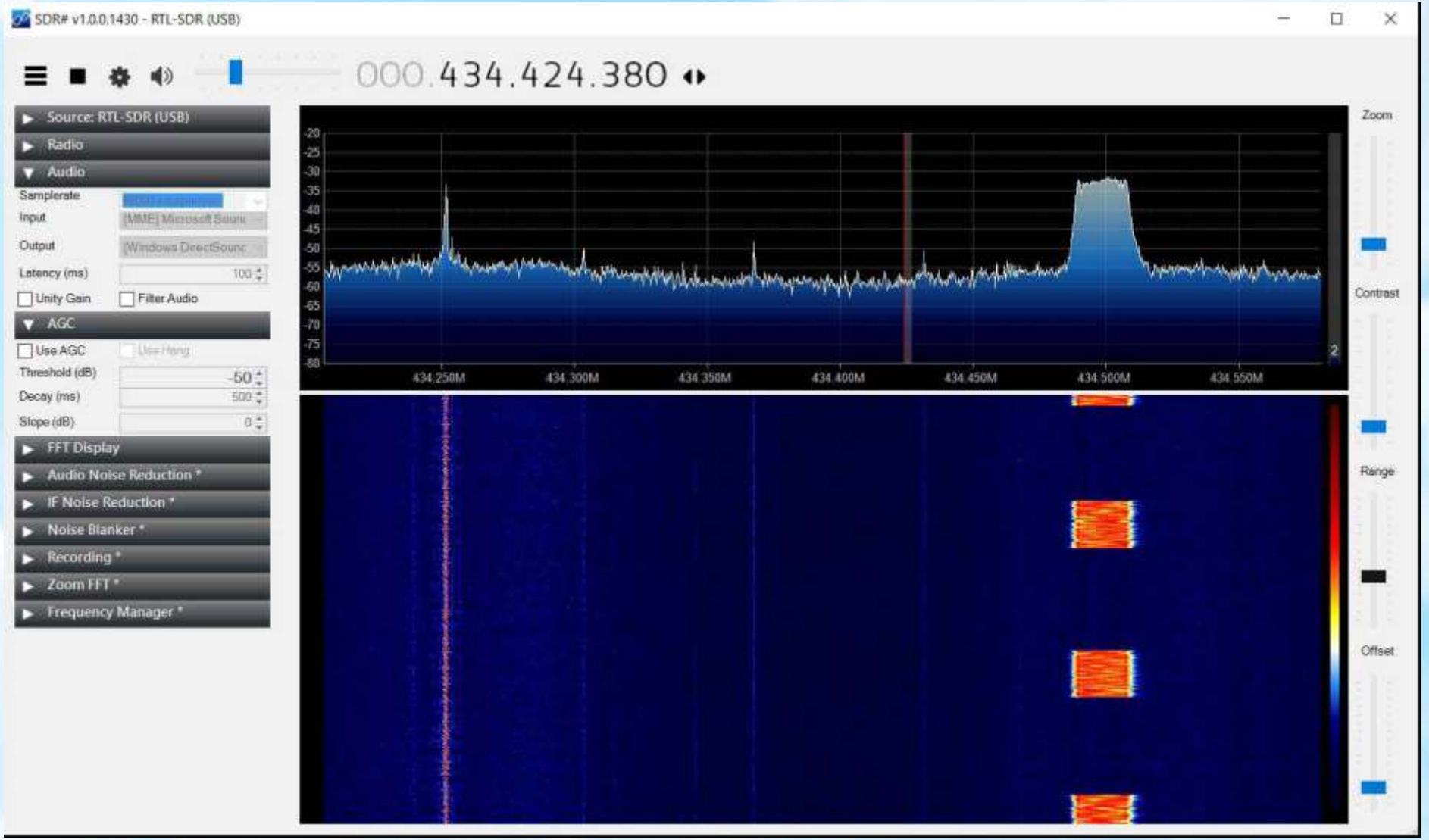
Note: This exemption/permission only addresses the flight safety aspects of the operation and does **not** constitute permission to disregard the legitimate interests of the landowner, other statutory bodies such as the Police and Emergency Services, the Highway Agency, local authorities (and their agents) or any other statutory body.

20190906226Perm1DMetBalloonHolyMillLongville 03-Sep-19

Sheep Dog - Father

- PC running an RTL-SDR radio receiver
- Android mobile running a hotspot
- Roof mounted homebrew antenna (Dave)
- SDR# primary interface
- Virtual Audio Cable
- Dl-fldigi FSK decoding

SDR# view of LoRa and RTTY



Sheep Dogs – Other Software

- 2 GPS position loggers for the Cars
  - One written in Qt
    - Based on a £6.50 Chinese GPS UBLOX 8 module
    - Logs car position to a file for later analysis
  - Other written in JSON (Ian)
- Excel position prediction spreadsheet
  - Based on the last few received sentences
- Live position plotting from Shepherd data

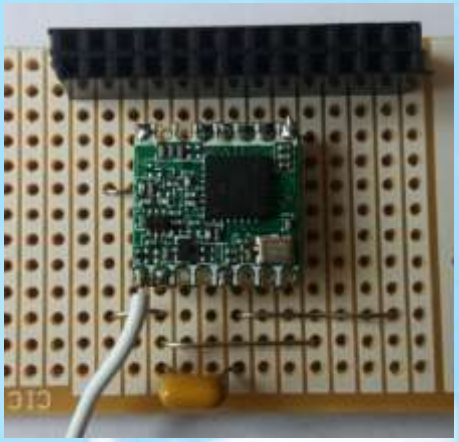
Sheep Dogs – Other Hardware

GPS Logger

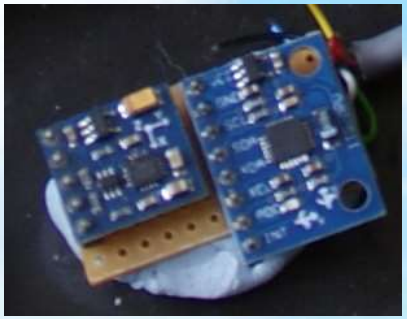
12v to 5V USB Hub

Sheep Dog Puppy

- Custom RFM98 LoRa Receiver board
- Raspberry Pi 2 B+
- 7” Android Tablet
- Custom Sensors



- compass
- accelerometer



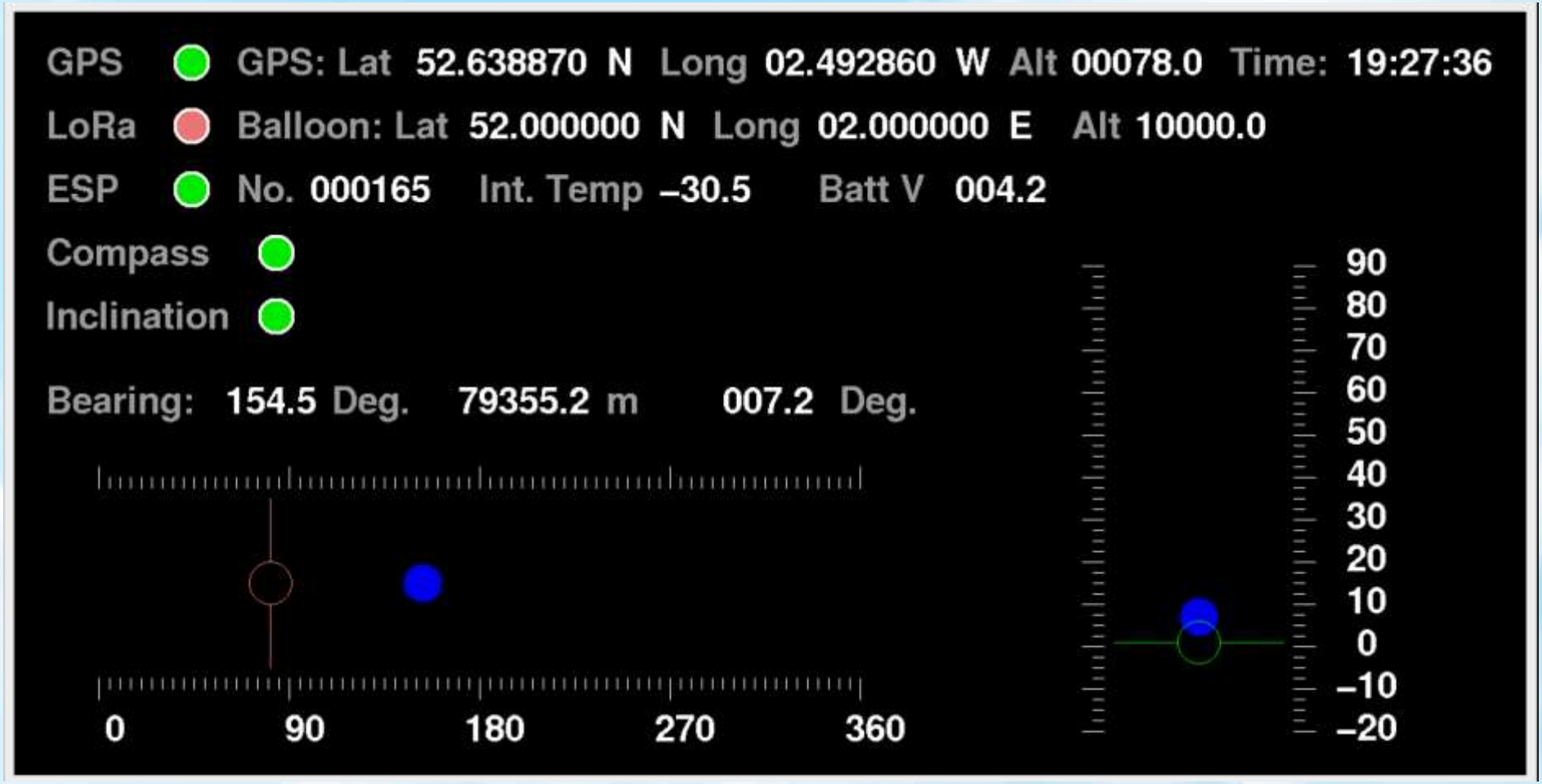
Sheep Dog Puppy - internals

- BlueNMEA app (on android tablet)
  - TCP socket to the RPI for GPS NMEA sentences
- VNC on the tablet for RPI display
  - RealVNC on tablet
  - TightVNC Server on RPI
  - Cross hairs to indicate direction
- Custom code on RPI
  - LoRA module control and reading (direct to balloon)
  - Link to Shepherd for internal web data (indirect to balloon)
  - Accelerometer and magnetometer compass give orientation
  - GTK 2.0 GUI
  - NMEA sentence parser
- Custom LoRa test code

Sheep Dog Puppy – Software

- I2C interface to the attitude sensors
- SPI interface for the LoRa module
- TCP-IP Socket interface to the Shepherd gateway via an HTTP page
- Socket interface to the tablet running BlueNMEA via direct data transfer
- Efficient NMEA sentence parser

Aliens vs. Sheep Worriers

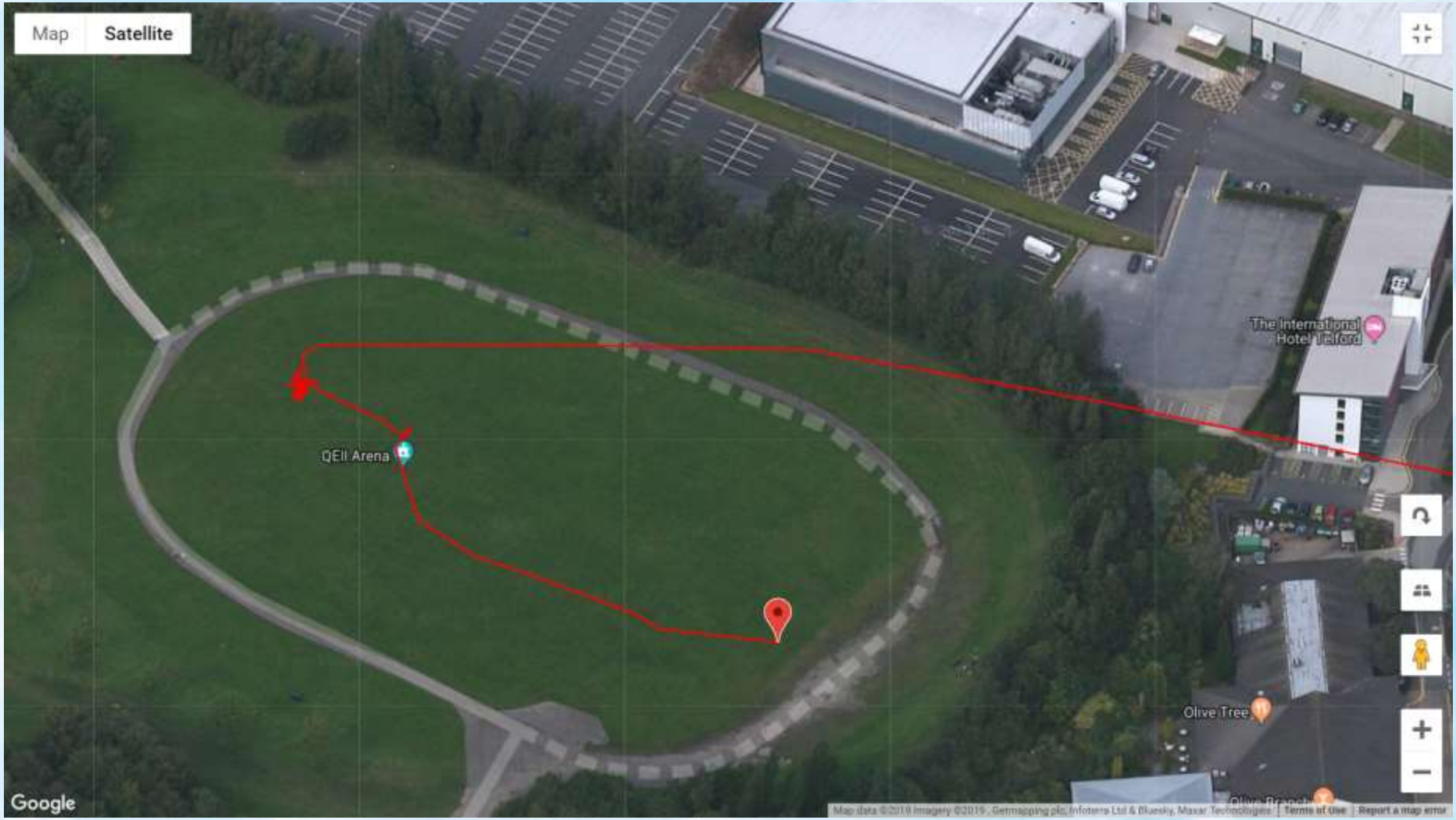


Other Stuff

- Qt based sentence parser for both LoRa and FSK Sentences
  - Outputs time vs. altitude, temperature etc. pairs as CSV values for Excel
- Javascript routines to allow fast web page creation parsing sentences

  http://myorangedragon.com/

Hot Air Balloon Take Off route



On The Road

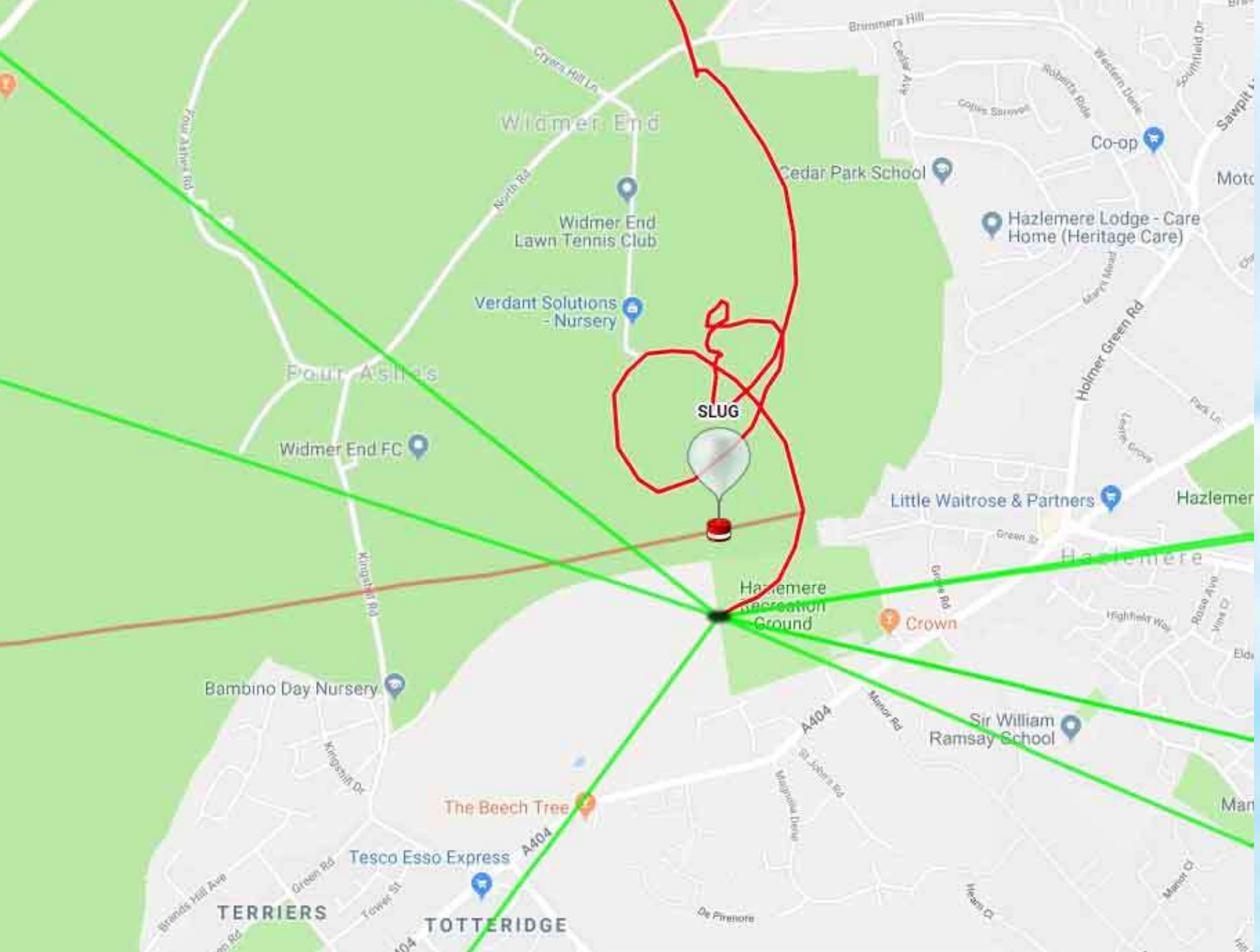
- We have now tracked 2 other HABs
  - Barnaby 2017
  - SpaceCamp 2018
- Attended 7 STEM outreach events:
  - TDARS Hamfest (2017, 2018, 2019)
  - Cosford Air Show (RAFARS) (2018, 2019)
  - Telford 50 and Telford 51
- Tracked our payload on 3 Hot Air Balloons
- And, of course, flown the actual payload …

STEM Response Team
STEM Response Team

Balloon Tracking

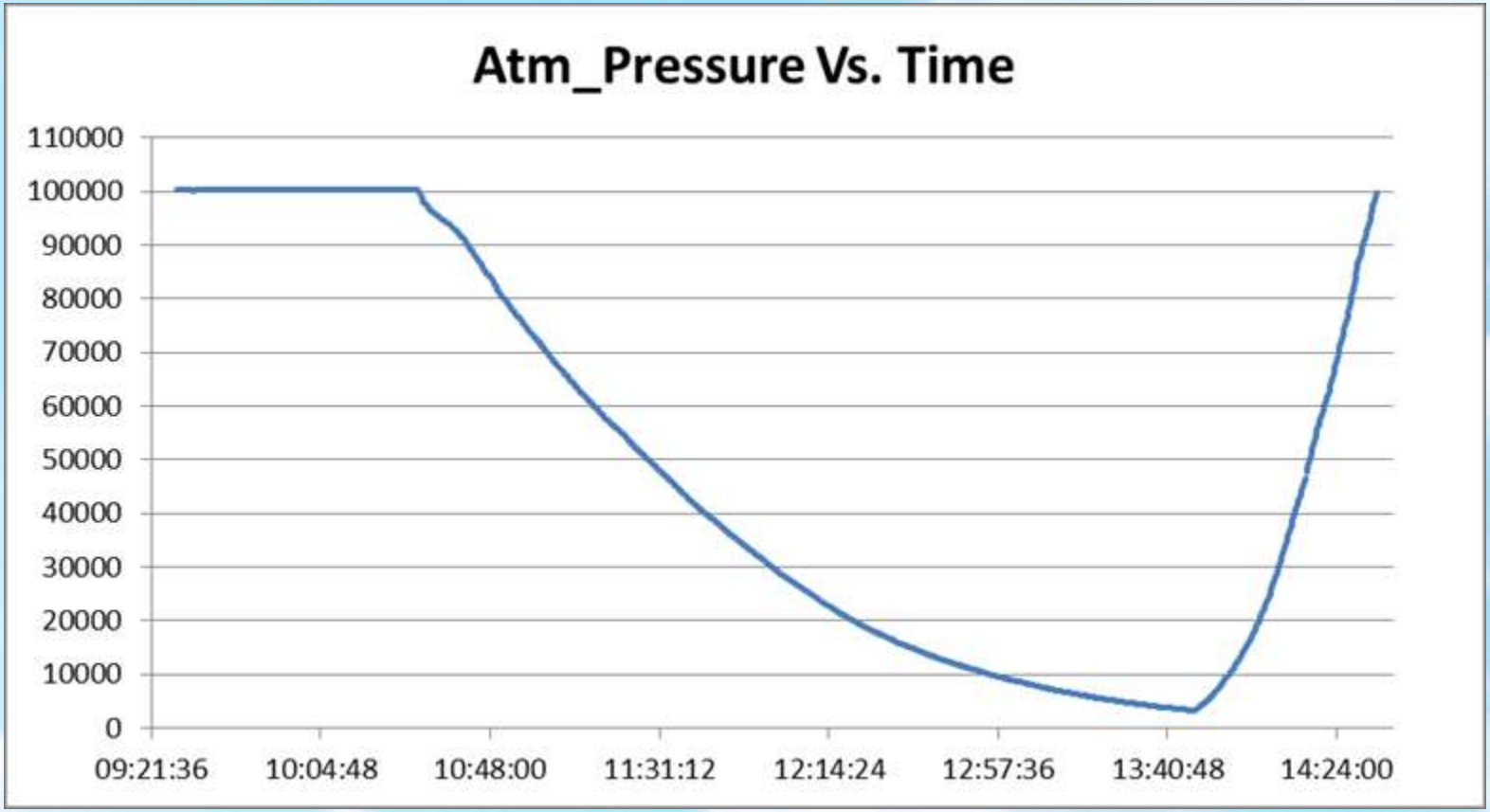
Up Up and Away – SLUG1 is go

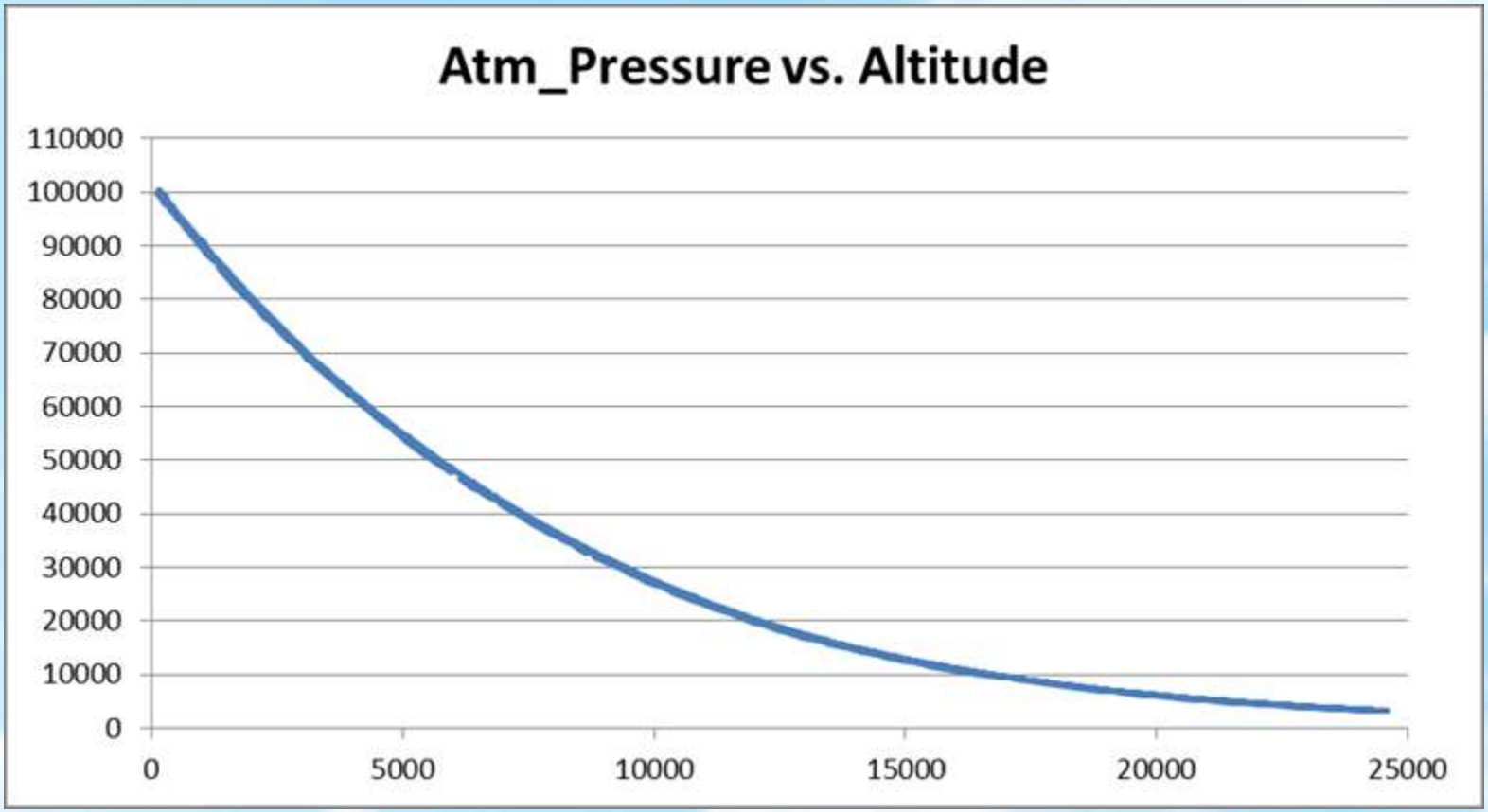
Pictures from the July 2019 Flight

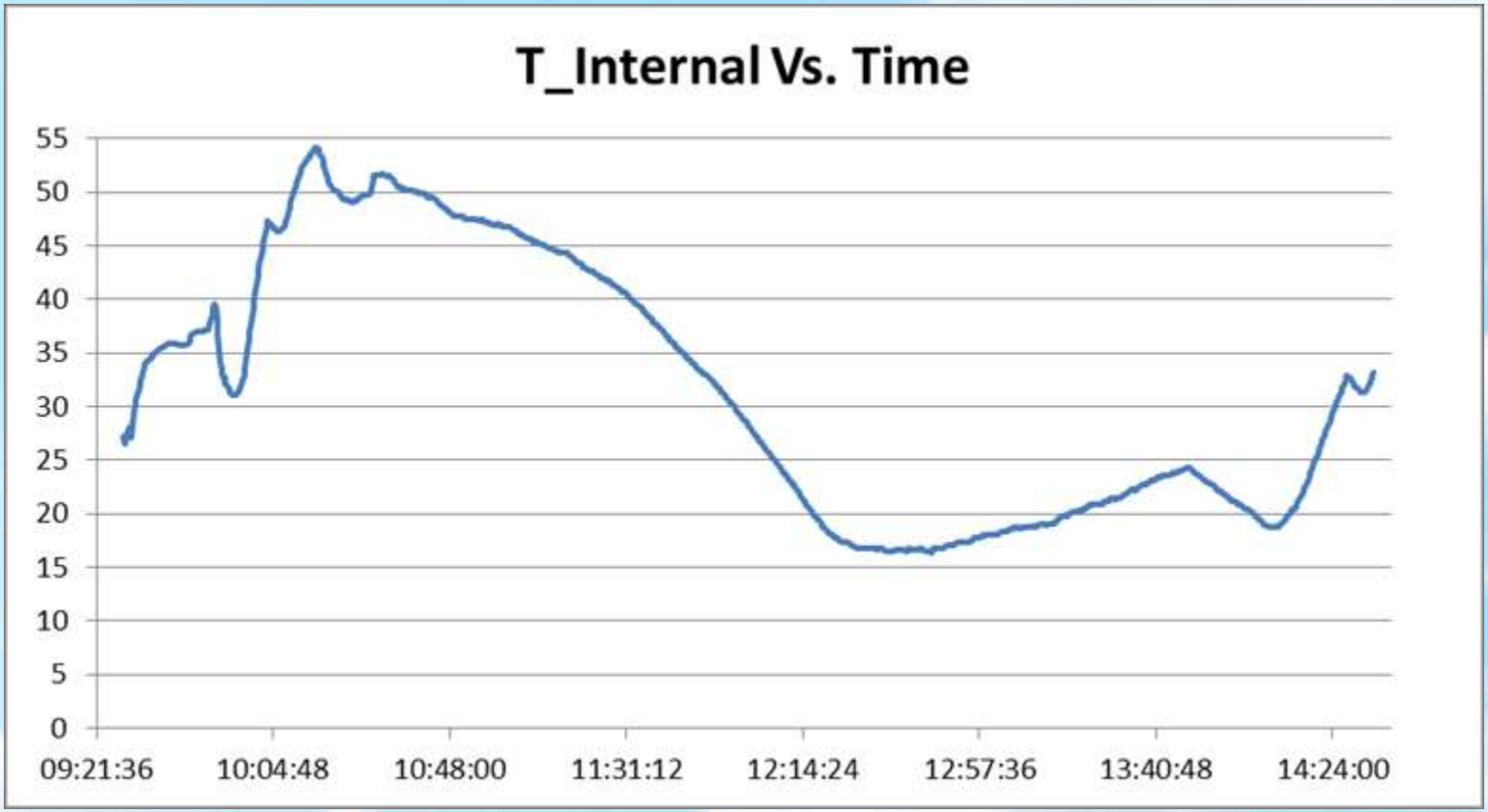


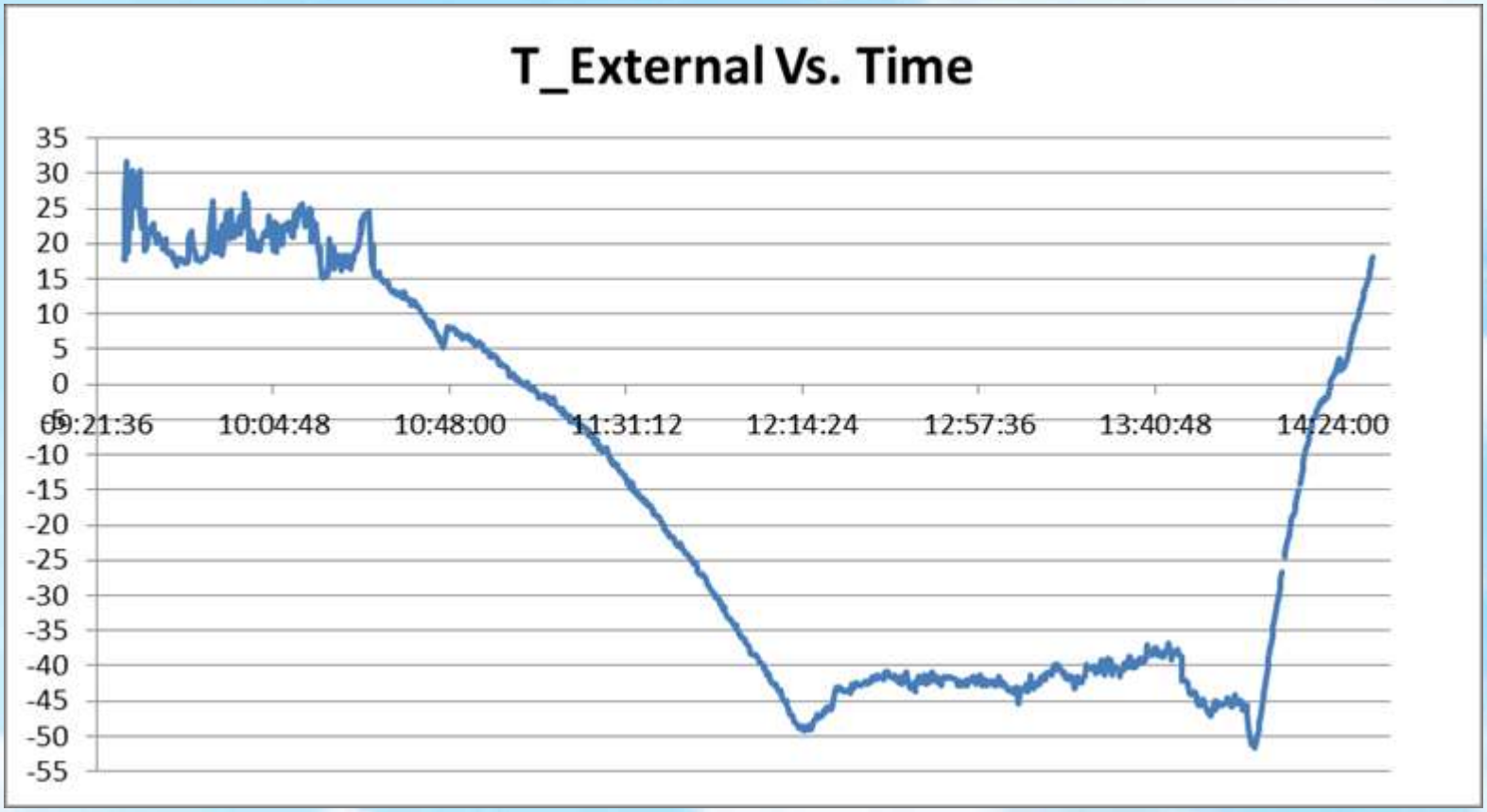
SLUG
Widmer End
Widmer End Lawn Tennis Club
Verdant Solutions - Nursery
Pour Asilas
Widmer End FC
Cedar Park School
Co-op
Hazlemere Lodge - Care Home (Heritage Care)
Holmer Green Rd
Little Waitrose & Partners
Hazlemere
Hazlemere Recreation Ground
Crown
Bambino Day Nursery
Sir William Ramsay School
The Beech Tree
Tesco Esso Express
TERRIERS
TOTTERIDGE
A404
Cryers Hill Ln
North Rd
Four Ashes Rd
Kingshill Rd
Kingshill Dr
Green Rd
Brands Hill Ave
Tower St
Manor Rd
St John's Rd
Magnolia Dene
De Pirenore
Brimmers Hill
Cedar Ave
Roberts Ride
Western Dene
Copes Sarovee
Southfield Dr
Park Ln
Green St
Grove Rd
Highfield Way
Rose Ave
Vine Cl
Manor Cl
Heam Cl

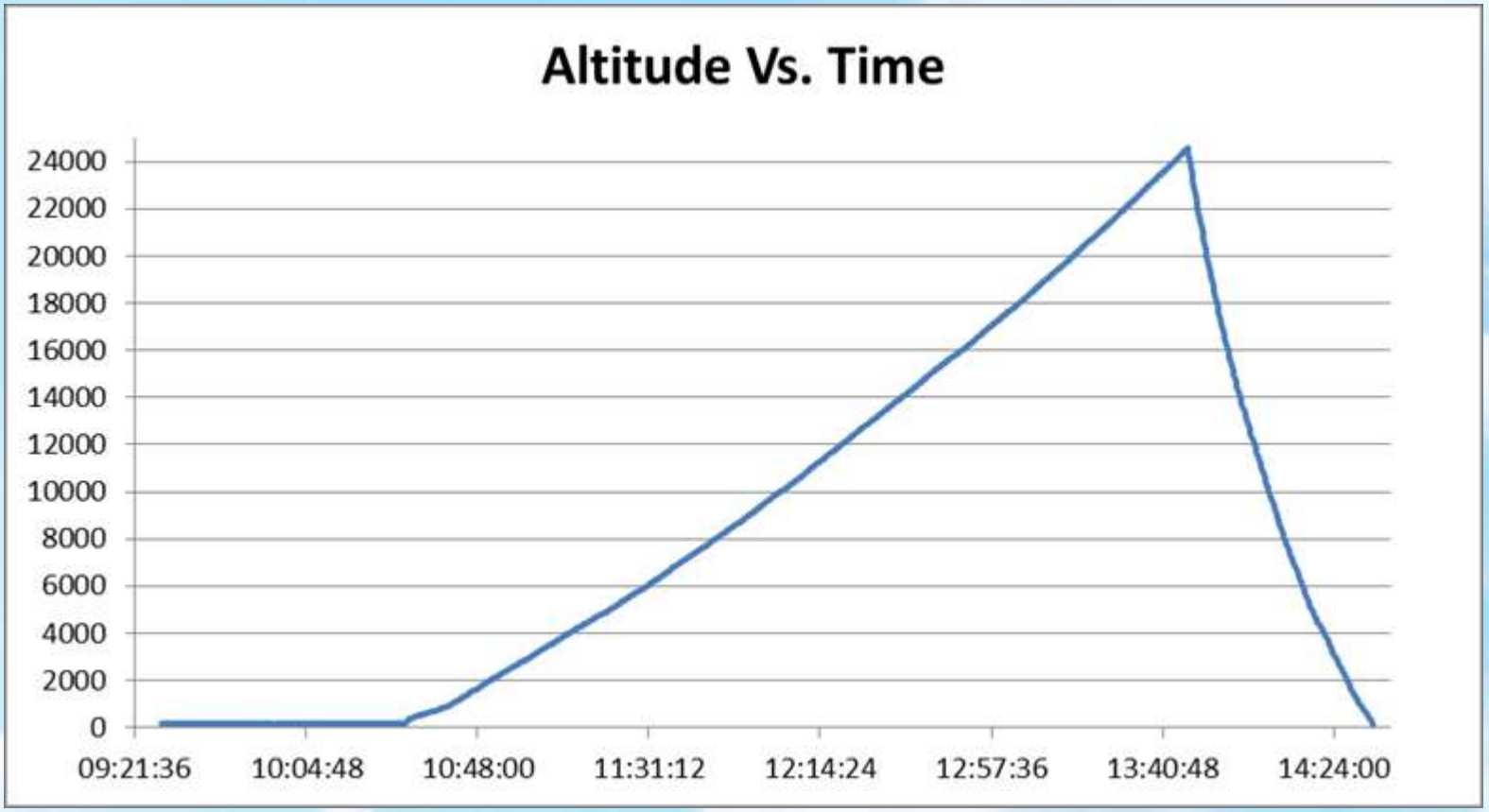
Up Up and Away – Data Analysis




Atm_Pressure vs. Altitude
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
0
5000
10000
15000
20000
25000

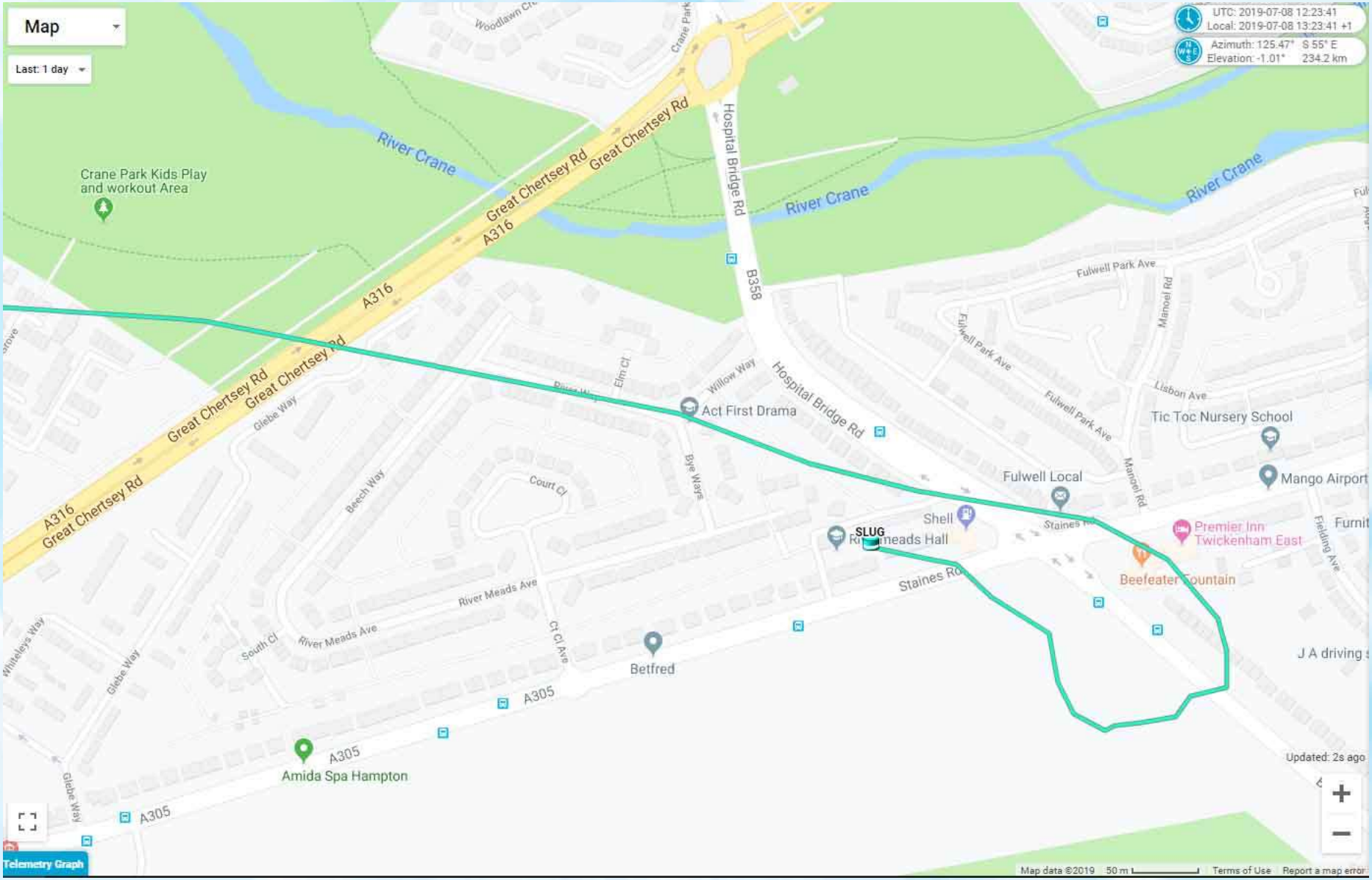

T_Internal Vs. Time
55
50
45
40
35
30
25
20
15
10
5
0
09:21:36
10:04:48
10:48:00
11:31:12
12:14:24
12:57:36
13:40:48
14:24:00


T_External Vs. Time
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
09:21:36
10:04:48
10:48:00
11:31:12
12:14:24
12:57:36
13:40:48
14:24:00


Altitude Vs. Time
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
09:21:36
10:04:48
10:48:00
11:31:12
12:14:24
12:57:36
13:40:48
14:24:00

22.24 Km away, 10mW RTTY, London

$$SLUG,1101,14:33:29,51.43919,-0.36236,00278,18,299,12,4.1,0.175,16.8,32.6,97818*0D30
$$SLUG,1102,14:33:47,51.43931,-0.36330,00193,16,308,12,4.1,0.175,17.5,32.9,98773*4650
$$SLUG,1103,14:34:04,51.43961,-0.36418,001H902,$$01!8DQ'2Ad"ItkbR 2XDCs#Nas-
me@pD>qB$QDSc7A23 @KI?#"W
Wud,dQ&D&pON*S_Yr$>e2sXB8_K#_)?1R0X)Nf F`fcYg@QOu'50Sl)j`(I)BWGJrnJ!0wadL\pCrS9X#g0
9<QJF
~,L&IhS`uUm1Zk-g:@v`(M1k6Bmv8i XCK$$p;bPV~adFm I:c;EP=n23!R:O%8N\hL0YQD@q*El%-
!0!>%`#Q0E@A CR`O~up.'e, bJP::{u|cujD05BGL[<>!BHU\
ec,f.0fJDSfSTARd@n\8 D[9zf: m5O[jhHlkToq8[fI@TQDfXd}D..@(
pC3,6}5tWMAg\OF)^jpz?i3-8J5@k M3LLI'c|
xTY*:G4q>M3zO);VZOHMrC74X)Ye&
p1m!K XA~PyDIr{/[


Map
Last: 1 day
UTC: 2019-07-08 12:23:41
Local: 2019-07-08 13:23:41 +1
Azimuth: 125.47° S 55° E
Elevation: -1.01° 234.2 km
Crane Park Kids Play and workout Area
River Crane
Great Chertsey Rd
A316
Hospital Bridge Rd
B358
Fulwell Park Ave
Manoel Rd
Lisbon Ave
Tic Toc Nursery School
Mango Airport
Act First Drama
Willow Way
Elm Cl
Glebe Way
Beech Way
Court Cl
Bye Ways
Fulwell Local
Shell
SLUG
Premier Inn Twickenham East
Beefeater
Staines Rd
River Meads Ave
South Cl
Cl Ave
Betfred
A305
Amida Spa Hampton
Updated: 2s ago
Telemetry Graph
Map data ©2019 50 m
Terms of Use
Report a map error

Google Streetview of Landing Co-ords

Up Up and Away – SLUG2 is go

Pictures and Data from Sept 2019 Flight

OM
Sharps

Questions