

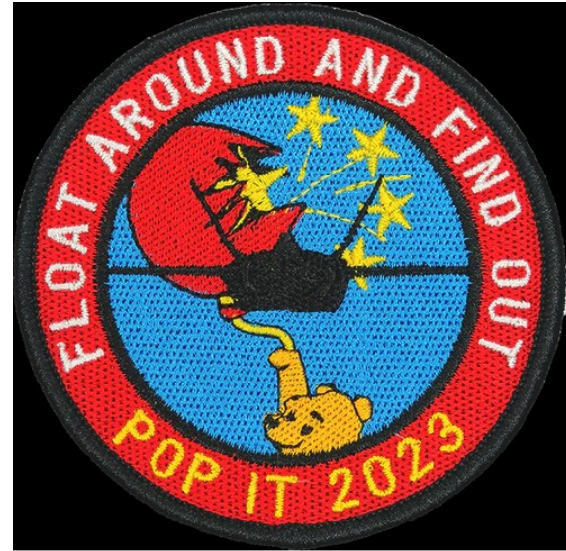
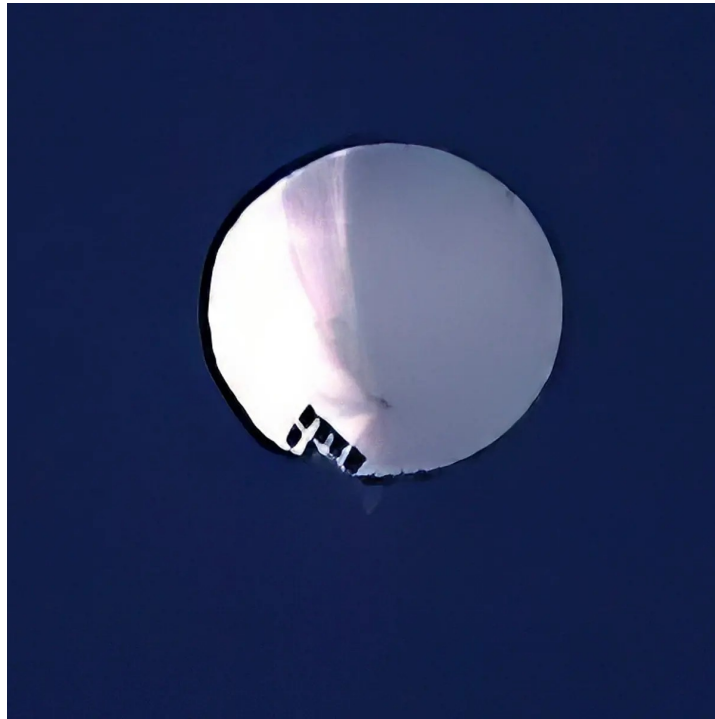
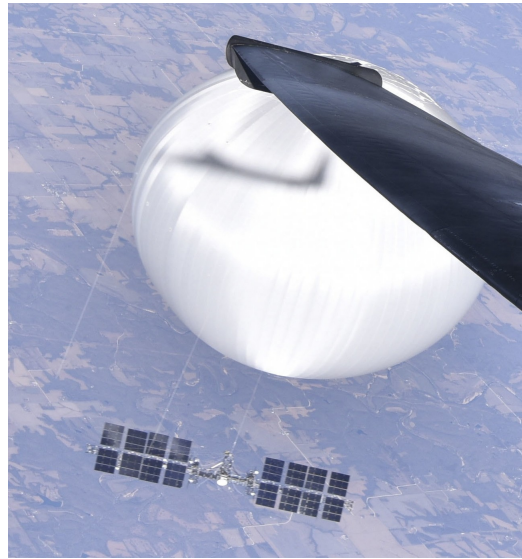
Amateur Radio Ballooning in the Bay Area with SF-HAB

Martin Rothfield W6MRR <https://sf-hab.org>

Foothills Amateur Radio Society

8/22/2025

RIP: Chinese Spy Balloon & K9YO-15 (Northern Illinois Bottlecap Balloon Brigade)



The Law(s)

PV=nRT

Density = Mass/Volume

FAA FAR 101

FCC Rules

ITU Radio Regulations

ITAR Regulations

Thermodynamics

Economics

Types of Balloons	HAB (Strechy)	Superpressure (Inelastic)
Flight duration	~4 hours	Days to Months
Goal	High altitude	Around the world Long endurance
Altitude	Up to ~120k feet, then down	Constant at ~43k feet
Payload mass	Up to 12 lbs	10 to 20 Grams
Gas Needed	Large Tank	0.5 l
Comms	APRS	WSPR
Payload recovered?	Yes (usually)	No
Balloon material	Latex	Multilayer plastics
Power	Batteries	Photovoltaic
Science opportunities	Short duration tests	Developing for long duration

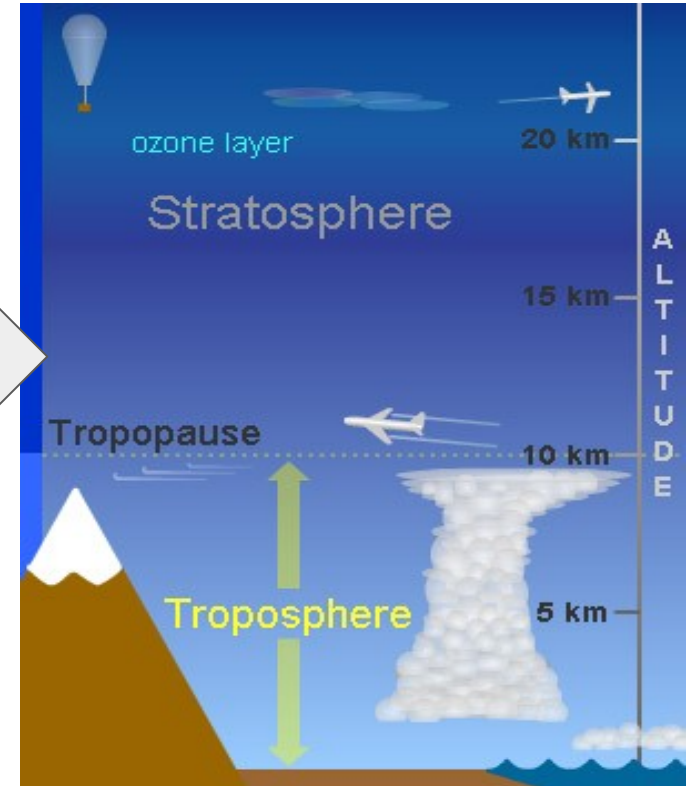
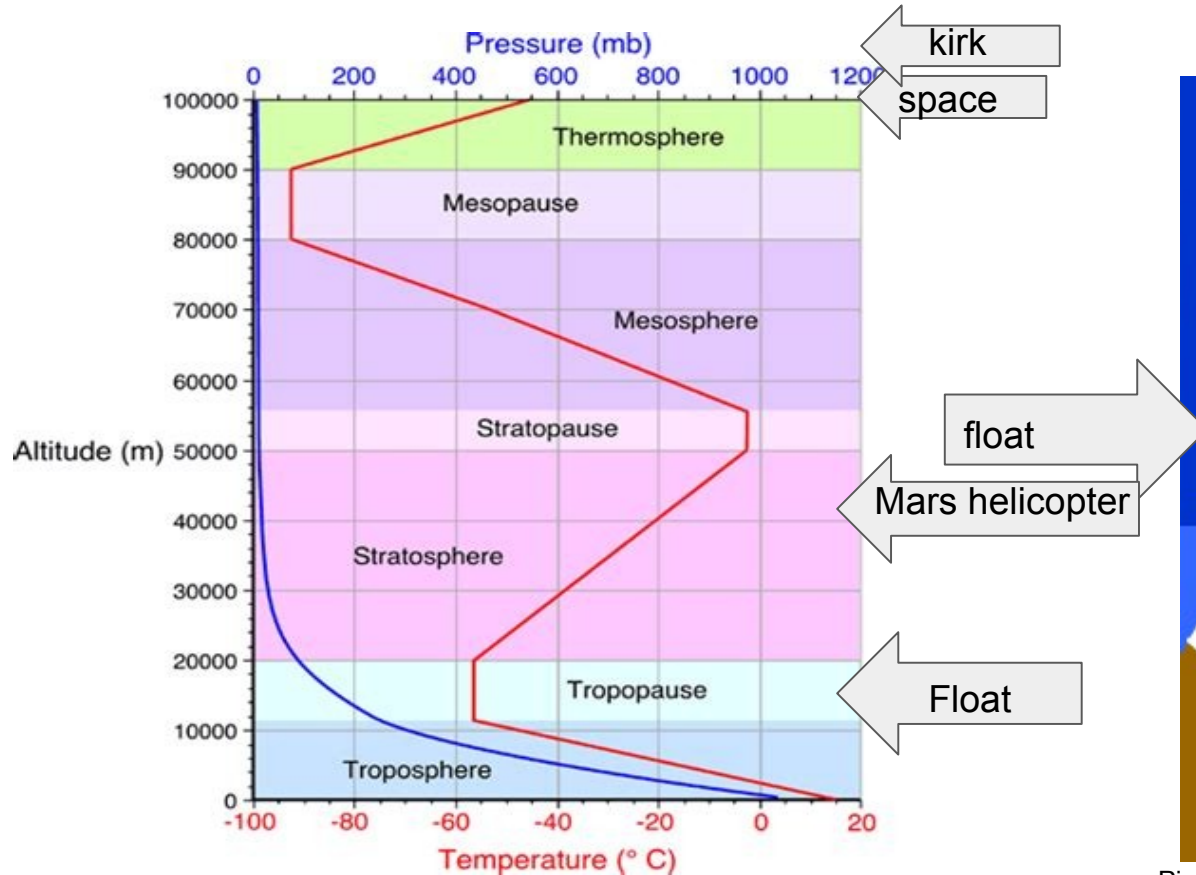
From HABs to Picos



Other type of balloons



Where Does a Balloon Float?



Picture taken from <https://scied.ucar.edu/atmosphere-layers>

How Balloons Float (and Burst)

- The density (volume/mass) of an object is less than the fluid it is immersed in
- The pressure inside a balloon exceeds envelope strength - pop!
- Pre-stretching the balloon increases volume but not weight - flies higher

The Spreadsheet float1g predicts the float altitude

float1g.ods - OpenOffice Calc

File Edit View Insert Format Tools Data Window Help

Calibri 11 B I U

B1

SuperPressure Balloon float calculator (by Steve Randall) Version 1g - 17/11/2020

Gas Density Table in Kg/cu m
at 101.325kPa at 15 deg C

Gas	Density (g)	Free Lift vol (cu m)	SP balloon weight (g)	Payload Weight (g)	Gas Mass (g)	Total Mass (Kg)	Neck Lift (g)	Launch Gas Fill (cu m)
Hydrogen	0.0852	6.50	0.600	105.00	15.70	9.51275268	0.1302	22.2000
Helium								0.1116
Helium 97%								
Air								

System Density at float (Kg/cu m) 0.2170

free lift ratio (see [1]) 0.04991831

Use: Inputs in green cells
Results in arrowed pink cells

Inputs:

Gas - drop-down of the the type of gas you will use to fill the balloon (Hydrogen/Helium)
Free Lift - desired free lift - sets the amount of gas needed, float differential pressure and altitude
SP balloon vol. - the volume of the balloon (or total volume if multiple balloons) that you will be using
SP balloon weight - the weight of the balloon envelope (or total weight if multiple balloons)
Payload weight - weight should include everything that is not included in the balloon weight (so line, tape etc).

Version History:

1 - 0-65.5Km in 1m steps (02-02-2011)
1a - 0 - 100Km in 10m steps (03-02-2011)
1b - corrected table range lookup (04-02-2011)

1d - changed so user now enters desired free lift and gas fill becomes an output (20-10-2020)
1e - added superpressure calculation as verification. (see [1]) (20-10-2020)
1f - Added Superpressure Onset Calculation, results in ft, NASA model (tropo temp) error corrected (13-11-2020)

Float

Internal Pressure (kPa)	External Pressure (kPa)	Temp (deg C)	Altitude (m)
14.1751879	13.468449	-56.46	14330
			(47002.4 ft)

Differential Pressure at float (kPa) (psi) 0.7067 0.1025

Supper Pressure by [1] (kPa) (psi) 0.6723 0.0975

Superpressure Onset (m) (45952.8 ft)

Atmospheric Pressure (kPa) 101.325

Altitude at which the balloon envelope becomes full, superpressure starts and the ascent rate slows down into float

320 meters above inflation
0.3 Superpressure red line
0.0975 Superpressure, psi
33% % of superpressure at red line
664 Altitude to red line, meters

References:
[1] Superpressure Balloons for Horizontal Soundings of the Atmosphere V.E. Lally

Sheet 1 / 1 PageStyle_Calc STD Sum=0 100%

How to Launch

Find a wide open space free from trees or power lines

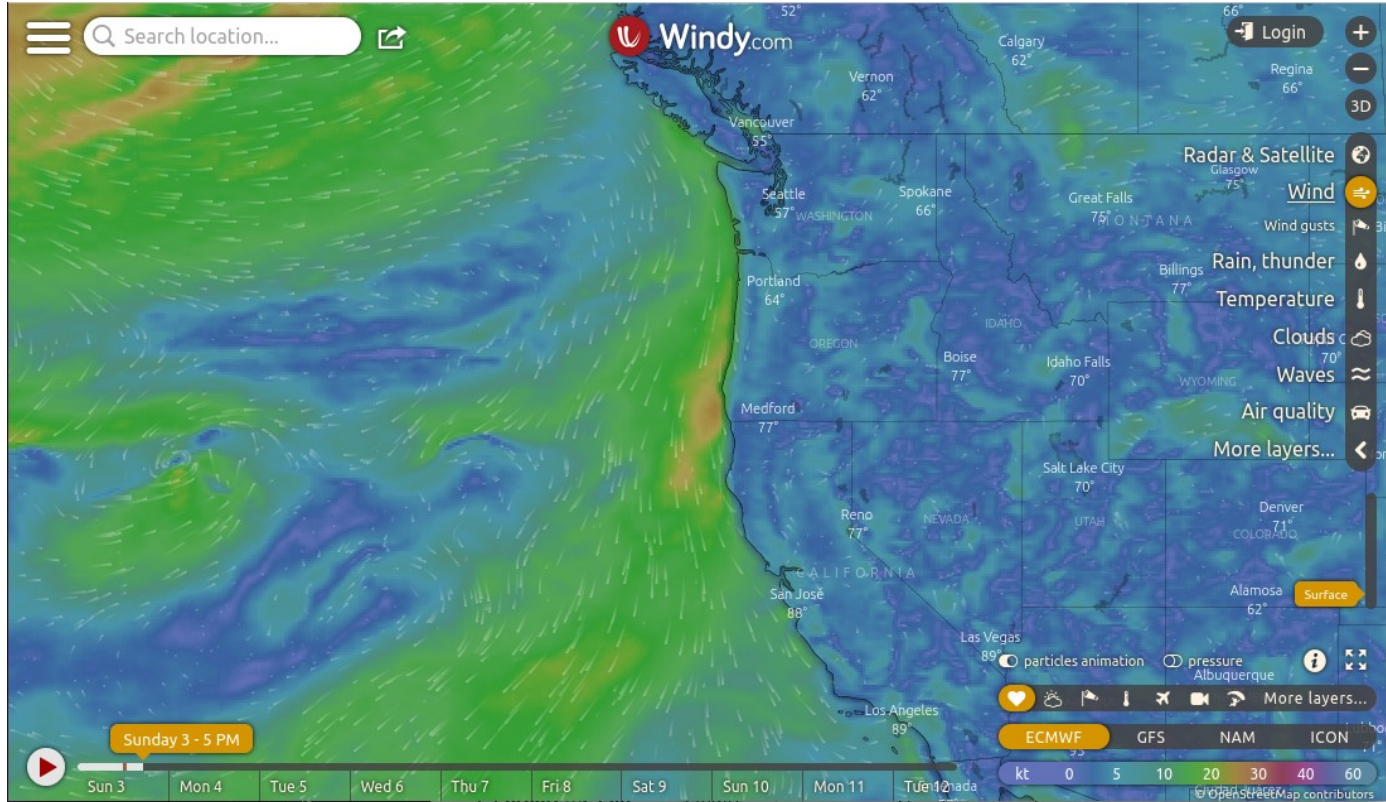
Low winds are needed (< 4 mph). Walk or trot with wind to your back.

No low clouds

Winter favors circumnavigation. Summer favors interesting wandering trips.

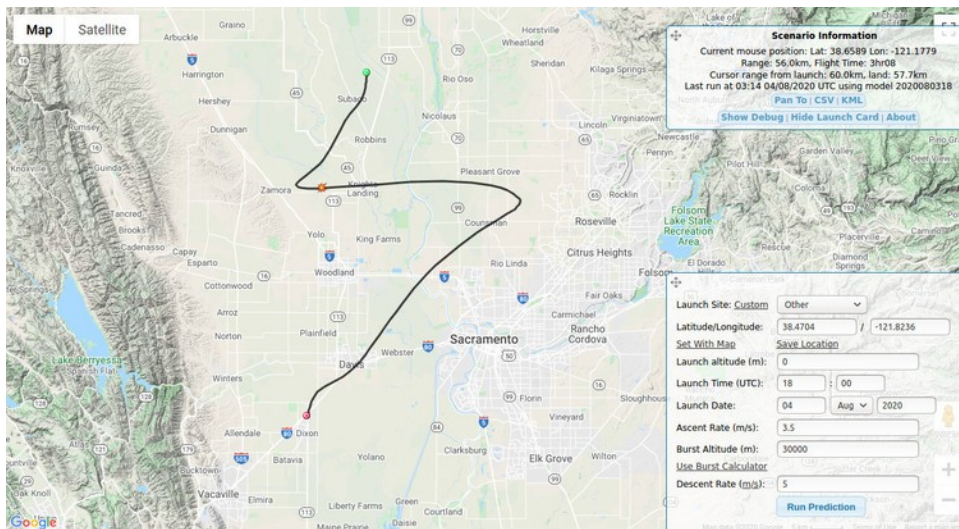
Use prediction software

Where do these maps come from?

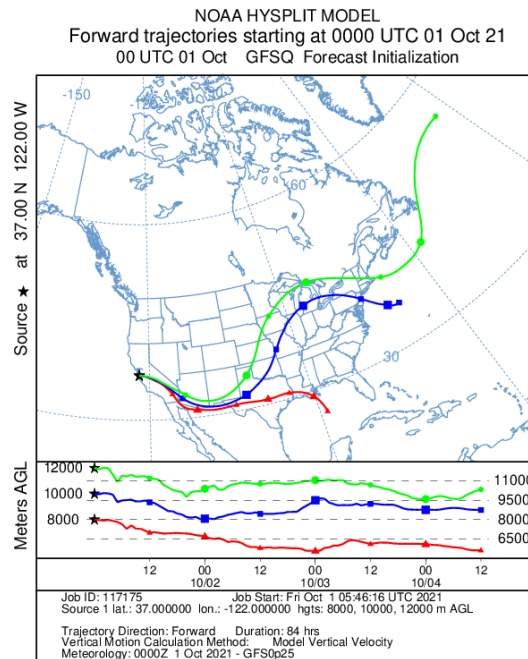


Flight Path Predictions

- How do you predict where a Latex HAB will land?
- What direction will a superpressure Picoballoon float?
- Where does [HYSPLIT](https://predict.habhub.org/) get data from?

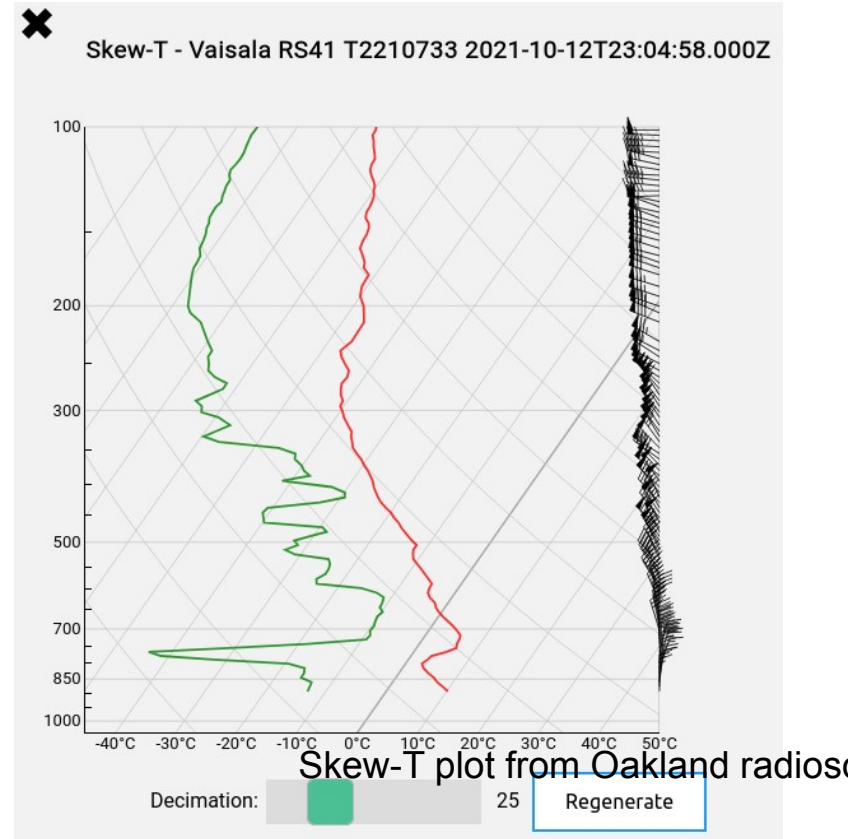


<https://predict.habhub.org/>



This data comes from Radiosondes

- Radiosondes directly measure the upper atmosphere wind, temperature, humidity, and pressure from ground up to ~30k meters (~100k feet)
- This data gets fed back into the Global Forecast System (GFS) model
- GFS is used for weather predictions, volcanic ash, manned “hot air” balloons, wildfire smoke movement



Radiosondes Directly Measure Upper Atmosphere Winds

- Small disposable transmitters on latex balloons
- Launched twice per day from ~1300 sites worldwide
- Our local radiosonde station is at the Oakland Airport
- Not amateur radio, but ham-adjacent at ~403 MHz or ~1680 MHz
- Vaisala RS41: 60mW, 403 MHz, 4800 baud GFSK, 84g (~3oz)



Vaisala RS41-SGP

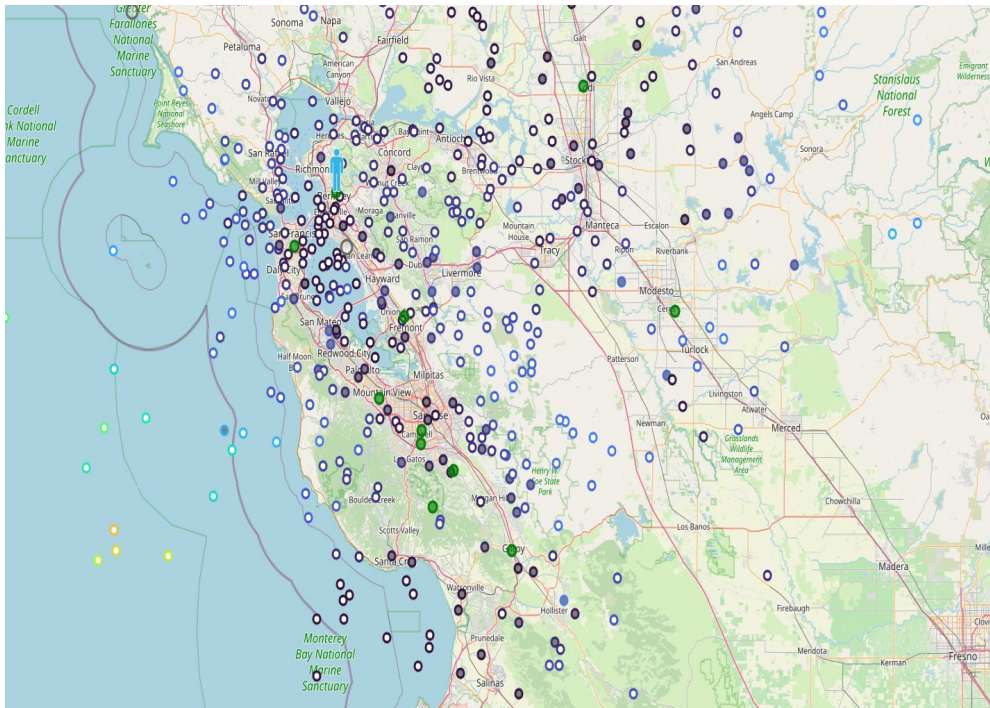
Typical Radiosonde Flight

- Radiosondes are launched at 1100 and 2300 UTC every day
 - 4am and 4pm Pacific time (until DST ends soon)
- Balloon ascends at ~ 5 m/s for 90 minutes, up to ~ 30 k meters (~ 100 k feet)
- Balloon bursts, and free falls for 30 minutes until it hits the ground

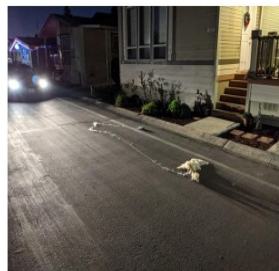


Where do the radiosondes land?

2025 OAK Landings



Radiosonde Recovery



Telemetry for Everyone

20 m WSPR - General

10 m WSPR & 70 cm APRS - Technician

Satellite (1811.25 MHz) SPOT - Unlicensed

LoRa 33 cm USA 863-870 MHz EU - Unlicensed

4FSK 70 cm - ISM ???

22 m ???

403 MHz - National Weather Service radiosondes

Never fly a cell phone to send data! - FAA Regulations prohibit

Different Types of Amateur Radio Position Reporting

	Automatic Position Reporting System (APRS)	Weak Signal Reporting System (WSPR)
Network	ARPS.fi (APRS-IS)	(AMSAT Argentina) LU7AA.org/wsprx.asp WSPRnet.org
Frequency	VHF - Typically 2m, 144.390 MHz (Line Of Sight)	HF - typically 20 m, 14 MHz (Skywave)
Antenna	17" guitar string	34 feet 34 AWG magnet wire dipole (human hair is 44 AWG)
Modulation	Binary AFSK over FM ~ 1200 bps (Bell 202 modem 1976 standard)	4-ary CPFSK, 50 bits/2 minutes = 0.42 bps
Data Payload	Up to ~1,000 bits	50 bits
Power	typically 0.5 W	Typically 10 mW
Range	Range circle in miles $\sim 1.2 \cdot \sqrt{\text{height in feet}}$, 40 k' = 240 mi	Beyond line of sight
Position	Within ~60 to 100+ feet	4 digit grid square
Telemetry	Altitude, pressure, temperature	extra 2 digit grid square + using type 2 or 3 messages
Sound	AFSK	WSPR CPFSK
Weight	6 g 0.5 W transmitter	10 mW TXCO & Si5351 synthesizer
Efficiency	0.001 Joule/bit	0.02 Joule/bit

APRS Data

[Station info](#) · [map view](#) · [info](#) · [telemetry](#) · [weather](#) · [raw](#) · [status](#) · [beacons](#) · [messages](#) · [bulletins](#) · [browse](#) · [moving](#) · [my account](#)

Callsign, ship name or locator: **Completed generating statistics (took 0.016 s).**

It is possible to search using wildcards (*) after a prefix. Example: OH*

←

Ads by Google

APRS station **K7HAK-11**  - [show graphs](#)

Comment: 10 3.86 -7 11466 5

Location: 60°23.43' N 146°06.81' W - locator BP60WJ63JR - [show map](#) - [static map](#)
16.0 miles Southwest bearing 229° from Cordova, Valdez-Cordova Census Area, Alaska, United States [?]
51.7 miles South bearing 171° from Valdez, Valdez-Cordova Census Area, Alaska, United States

Last position: 2021-03-30 18:26:06 PDT (187d 15h8m ago)
2021-03-30 17:26:06 AKDT local time at Cordova, United States [?]

Altitude: 37619 ft

Course: 54°

Speed: 53 MPH

Last telemetry: 2021-03-30 18:55:19 PDT (187d 14h39m ago) - [show telemetry](#)
Solar: 3.920 V, Temp: -6 C, Sats: 9, Lock: 1

Device: WB8ELK: Balloon tracker (tracker)

Last path: K7HAK-11>APELK0 via WIDE2-1,qAR,KL7JFT-5 **Seriously bad path:**

This station appears to be flying at high altitude and using digipeaters, which causes serious congestion in the APRS network. The tracker should be configured to only use digipeaters when at low altitude.

Positions stored: 1408

Other SSIDs: **K7HAK**  K7HAK-7  K7HAK-9 

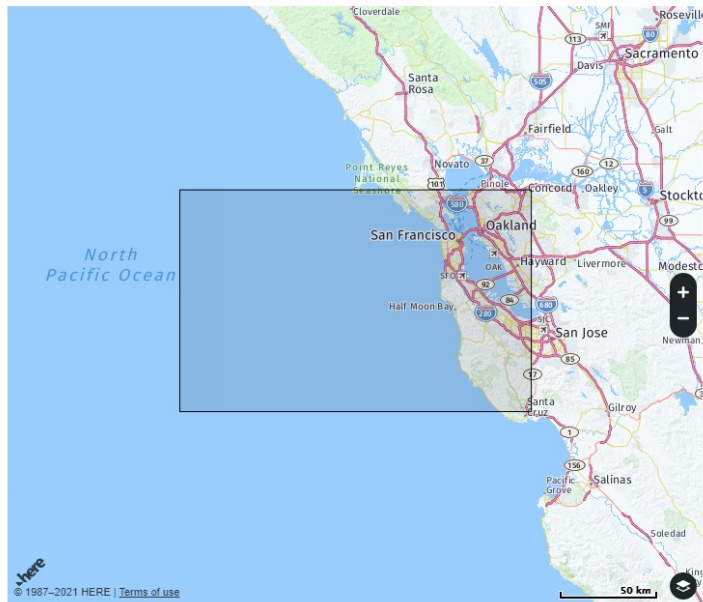
Stations near current position of **K7HAK-11** - [show more](#)

callsign	distance	last heard - PDT	callsign	distance	last heard - PDT
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BP60WJ63JR	15.0 mi	187d 14h 39m	BP60WJ63JR	15.0 mi	187d 14h 39m
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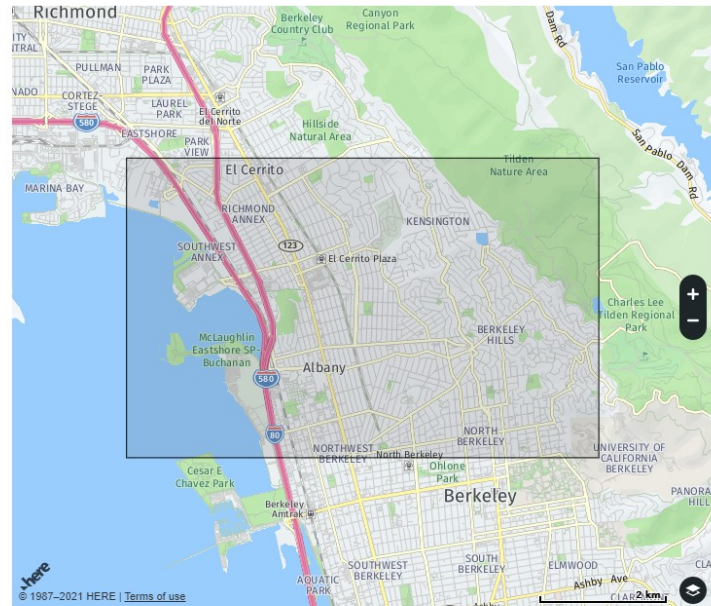
Maidenhead Locator System - Position Reporting

Grid Square: CM87



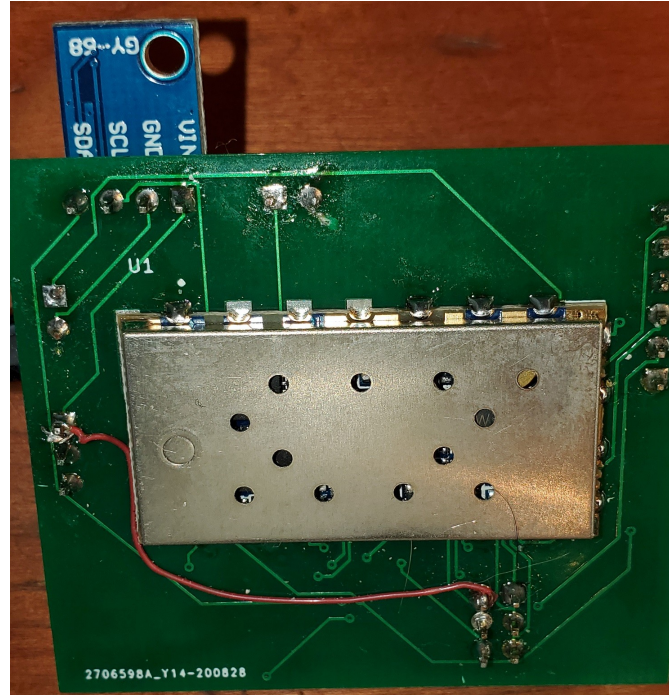
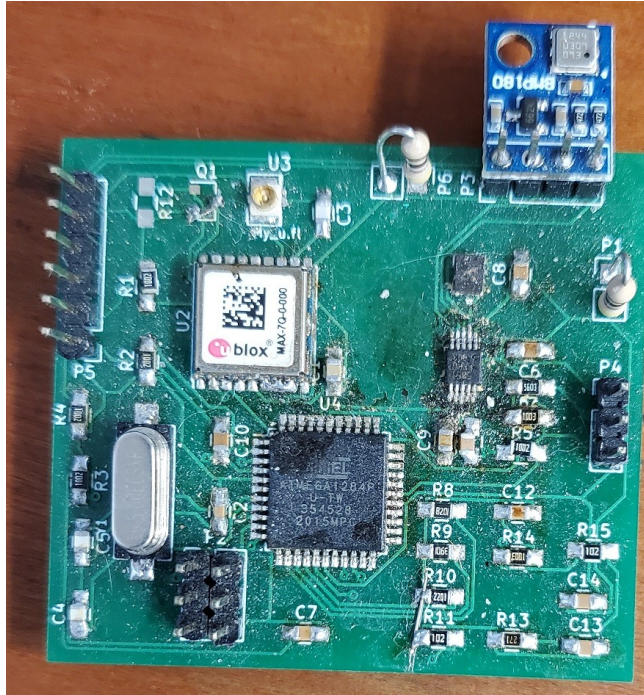
[Other Ham Radio / Amateur Radio pages](#) by K2DSL on Levinecentral

Grid Square: CM87uv

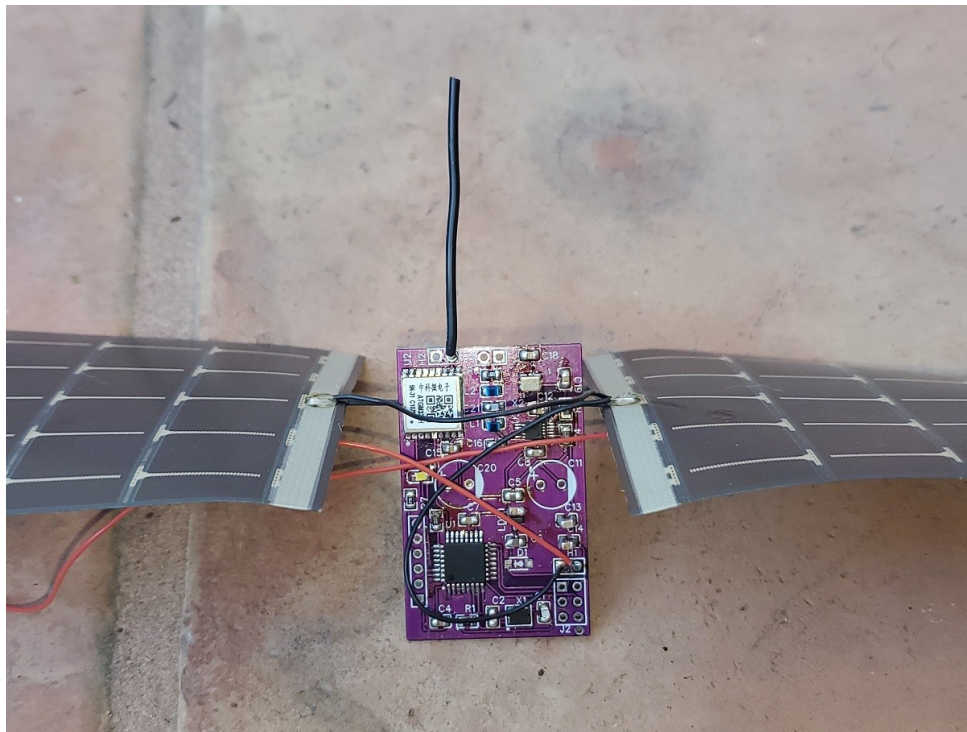


[Other Ham Radio / Amateur Radio pages](#) by K2DSL on Levinecentral

Tracker Generation 0



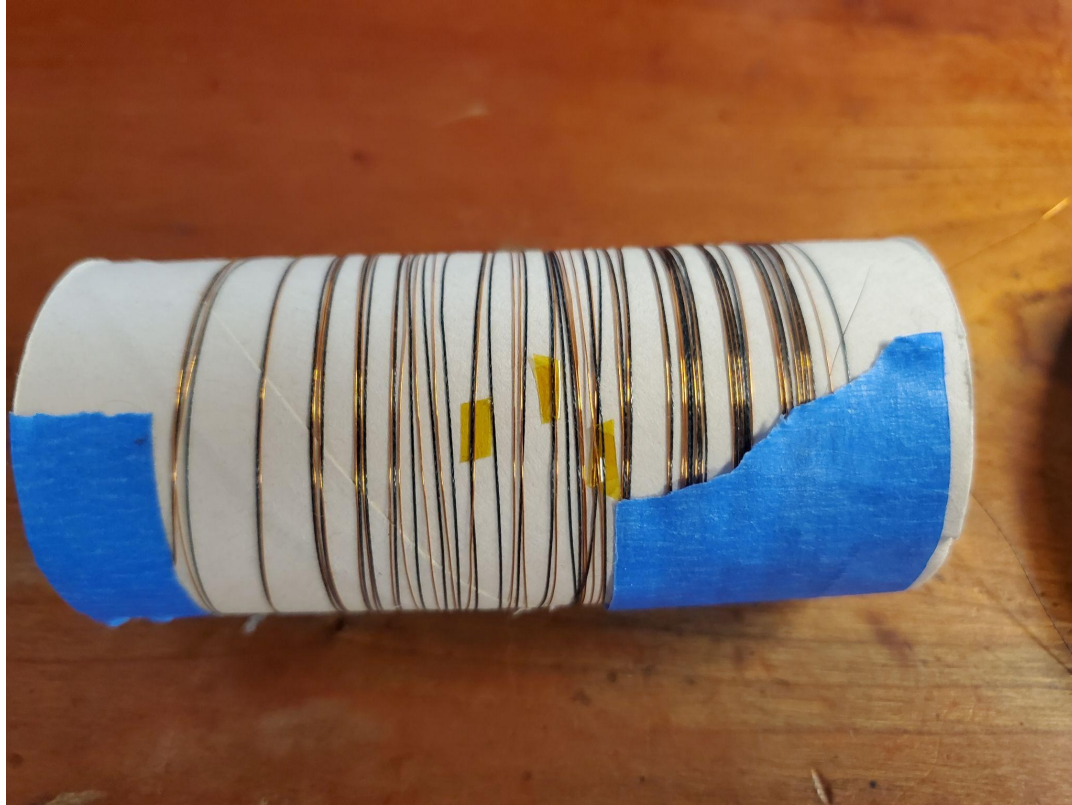
Tracker Generation 1



Tracker Generation 2



Half Dipole: 17' 1.5 g 36 AWG glued to fishing line



Current & Future Developments

PCB with Power Converter

AG6NS Tracker Software

Solar Arrays

HAB Payloads

- Particle Counter

- Crossband Repeater

- Controllable altitude

- Controllable azimuth

Questions

???