BALLOONS CARRYING HAM RADIO

321+ DAYS, 20 TIMES AROUND THE WORLD

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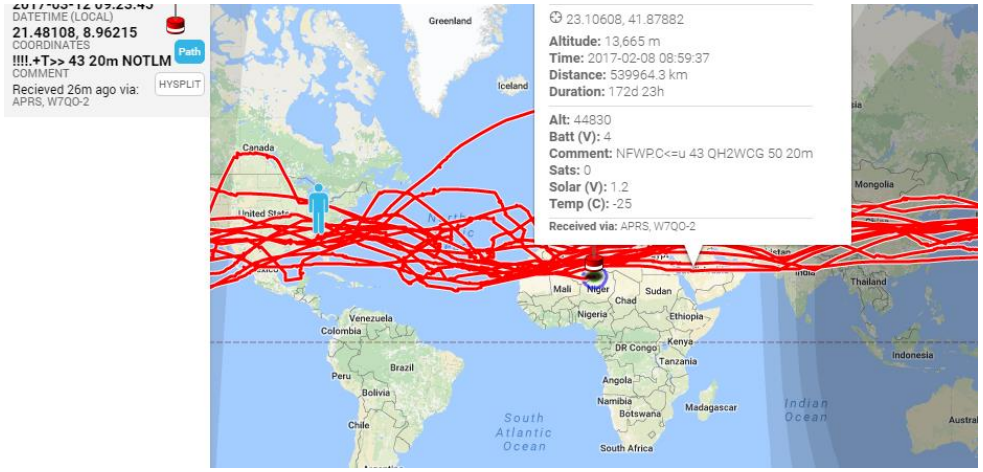
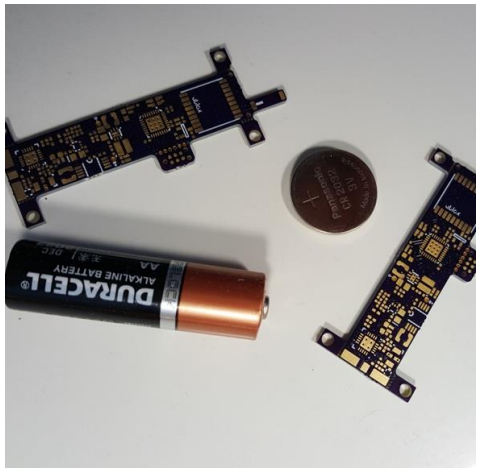




TOPICS

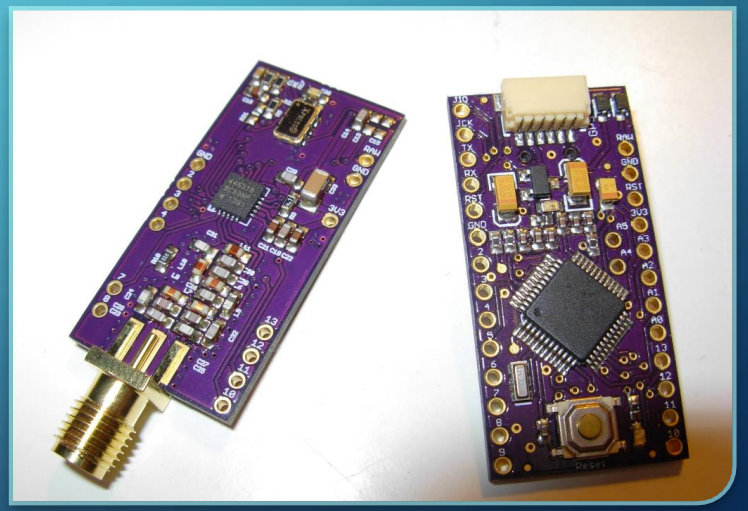
- What Started It All – natural evolution
- What Is Needed – a Lesson in CRAM (This Stuff is HARD)
- HW/SW Test Flight – Day 1
- The First 15 Days
- Status of Current Record Flight(s)
- Managing Expectations
- Where Does It Go From Here
- Records to be Attained

ABOUT ME

- Grew up in Utah, moved to Atlanta, via California in 1994 after surviving all kinds of natural disasters (Floods, Fires, Earthquakes and Riots)
- Retired from BellSouth in 2005. Started 2 companies that same year (RF management for buildings, and contract consulting on embedded computing designs)
- Designed and developed one of the first ARM based Arduino Mini compatible boards including an APRS compatible, FM radio module
- Designed and developed Commercial High Altitude Balloon flight controllers

WHAT STARTED THIS ADVENTURE – DRONES!

- Early Drones had flyaway problems
  - how to track and locate?
  - Miniature Radio for APRS with small processor as a tracking device
  - Designed and developed using Hobbyist tools and off-the-shelf components
- Evolved to become the first balloon controller



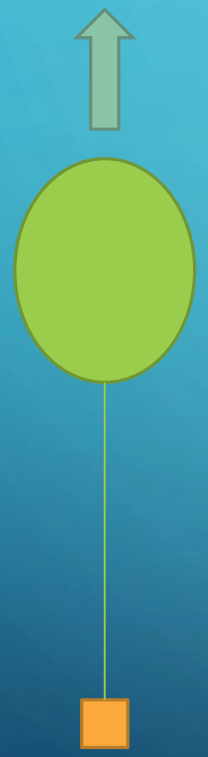
TYPES OF BALLOONS CARRYING HAM RADIO

- Up and Down flights
  - Latex Balloons in various volumes to reach different altitude, carry different weights of payload
  - Used for Imagery, experiments, research and data gathering
  - Duration is typically 2-3hours. Floaters don't last - with a few exceptions (due to UV deterioration of the latex)
  - Ends in a "Fox Hunt" to find and recover the Payload – typically via APRS

TYPES OF BALLOONS CARRYING HAM RADIO (CONT.)

- Floating Balloons (Super Pressure)
  - High Altitude Long Duration – days, weeks, years
  - Balloon – plastic material (Envelope size directly proportional to altitude and weight carrying capability)
  - Extreme challenges
    - Material & Construction of envelopes
    - Environmental
    - Power & Power consumption
  - Fire and forget – at the whims of the winds

SUPER PRESSURE BALLOON DYNAMICS



FreeLift – amount of lift after you lift all the below plus the weight of the lifting gas

Balloon – weight of material

Payload + tether weight

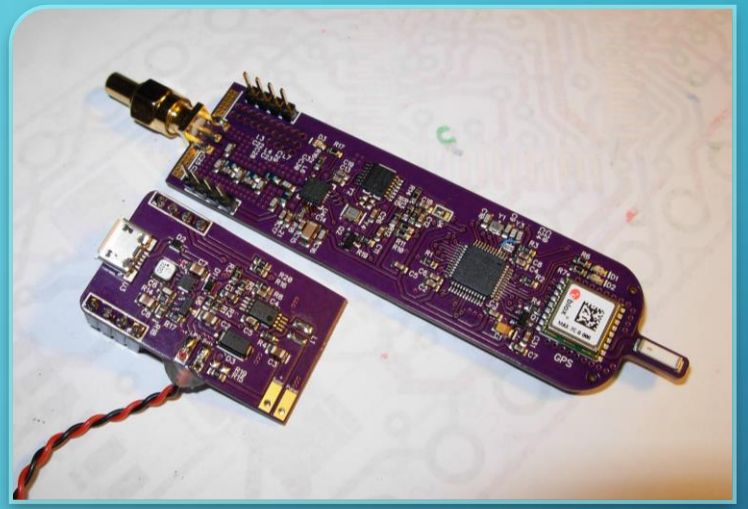
Zero freelift would hover the balloon and payload

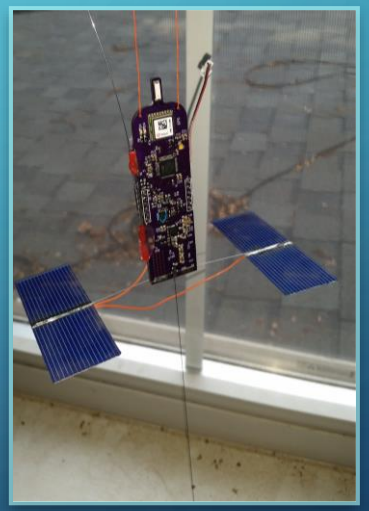
2-3grams of freelift would allow the balloon to lift an addition 2-3 grams of weight back to a hover

WHAT STARTED IT ALL

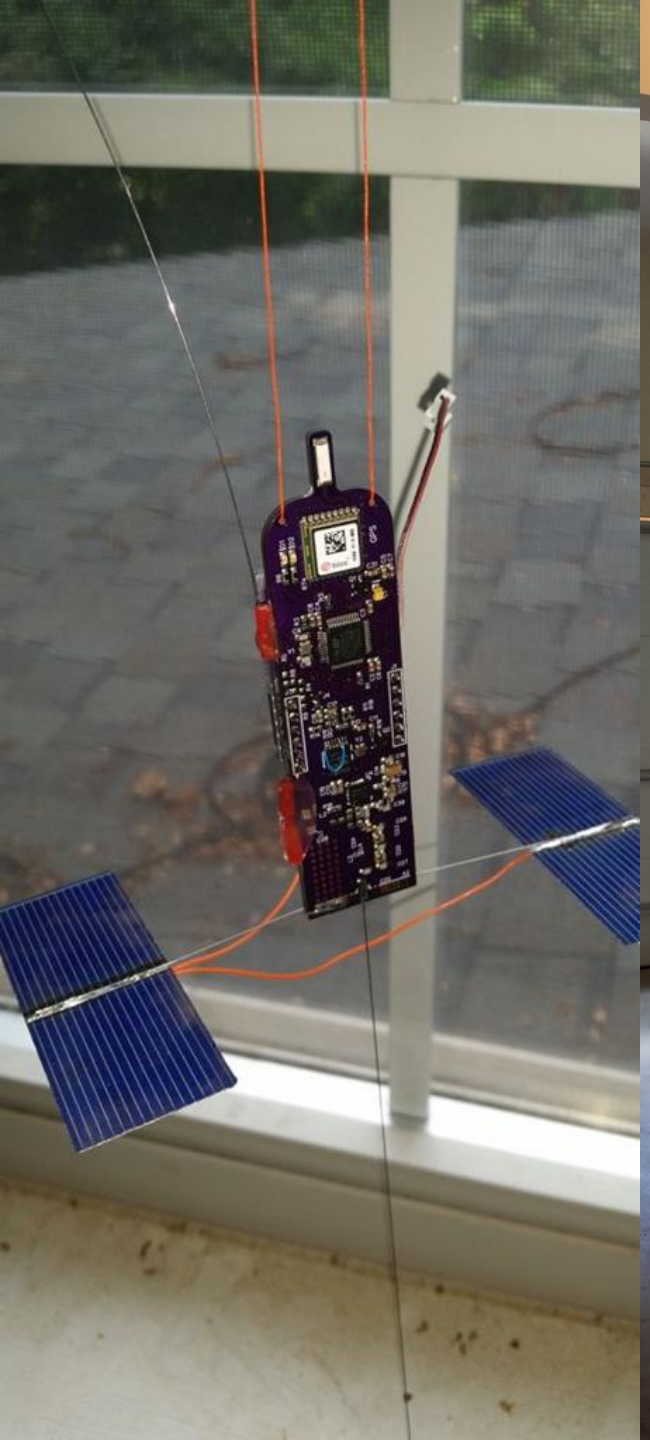
- Can we get an inexpensive party balloon around the world?
- 3+ years ago – first flight
- Custom Flight Controller
  - Ultra low power ARM based microprocessor
  - 142-1050Mhz frequency agile radio
  - Used true FM to make APRS tones
    - Modulated the LO
    - 10-100mW output (flew at 10mW)
  - GPS needs to work up to 50km
  - Solar – MPPT controller/SMPS
  - Single Cell – Boost Power supply
  - Software geofence for frequency control
  - Internal or external temperature sensor

- Floated at 25-28k Feet
- Weighed almost 25 grams (heavy)
- Needed ESD/Lightning protection





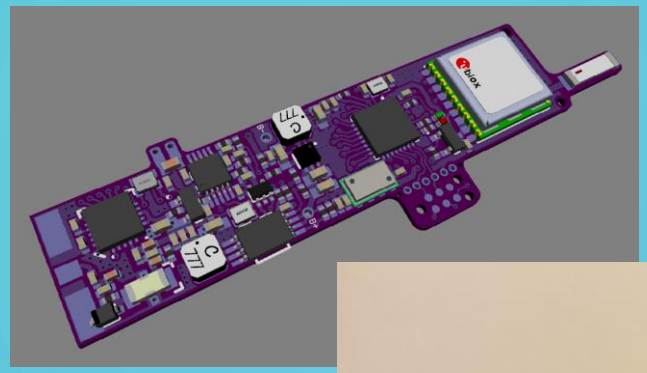
That First Launch

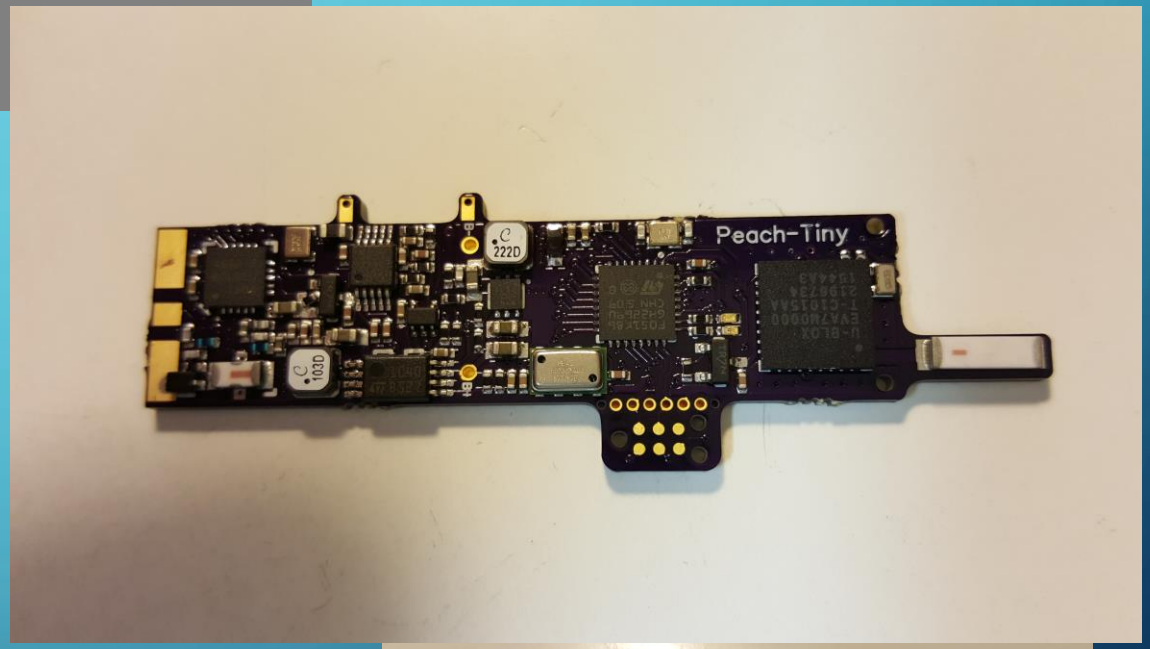


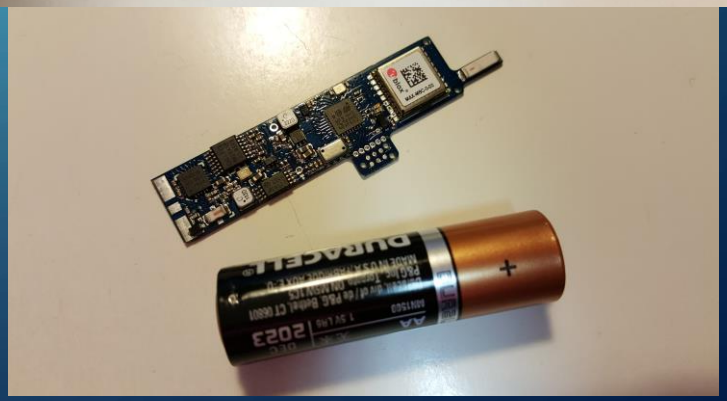
UP and downs of that first launch!

WHAT IS NEEDED

- Extreme low weight
  - ~1.5 grams or less
- Integrated Solar MPPT/SMPS
- Extreme low power consumption
  - Can run from a Supercapacitor/Solar
- Sensors
  - Position
  - Temp
  - Baro Pressure
- Anywhere Communications
  - APRS & WSPR (dual radios)
  - Frequency agility 2.5khz to 1050Mhz
  - Frequency Stability - TCXO
  - Geofenced QSY based upon local operating practices w/lockout
  - ESD/Lightning protection

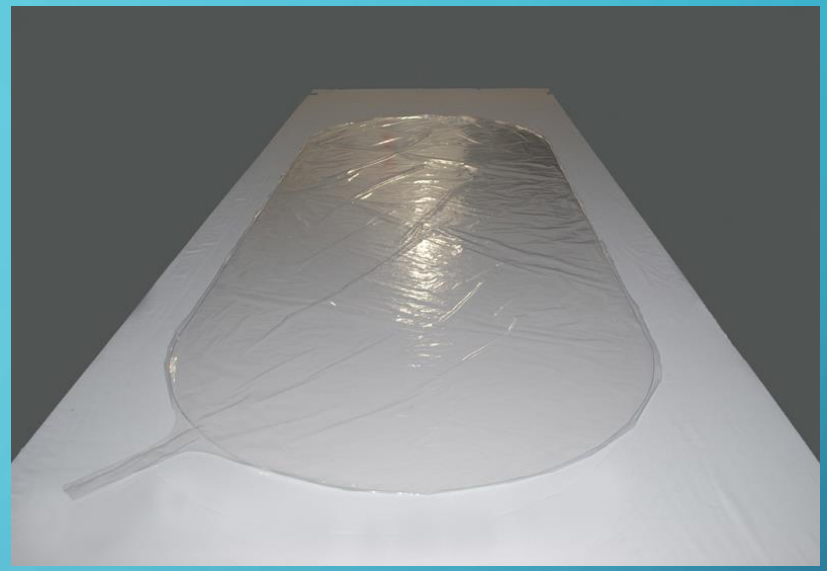


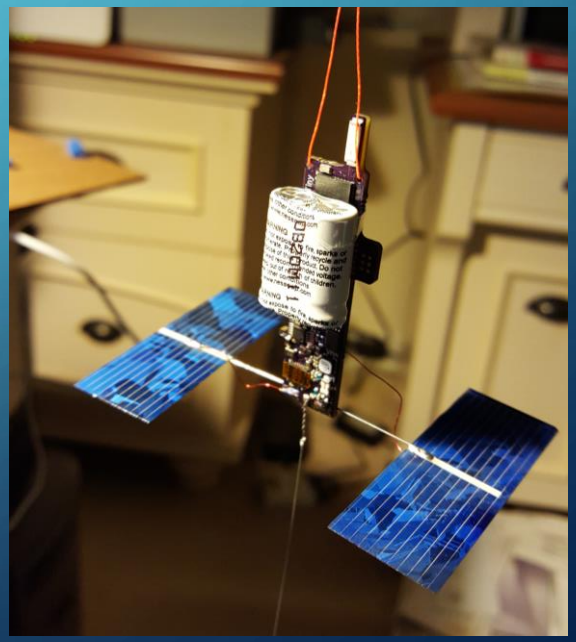




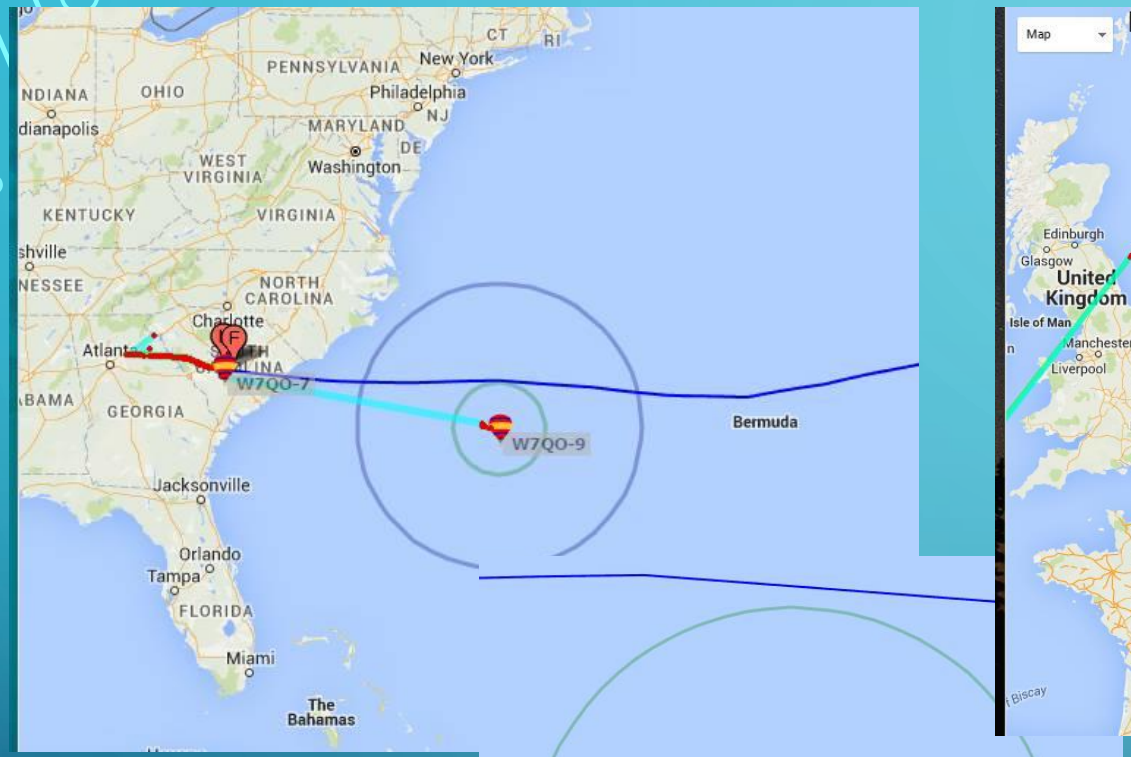
HW/SW TEST FLIGHT – DAY 1

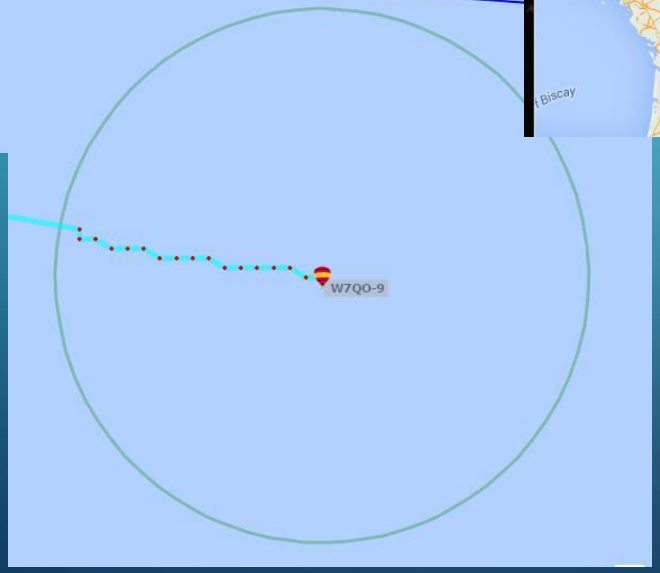
- Everything's New
  - Tracker
    - 9 grams total weight
    - No battery, uses a Supercapacitor/Solar
    - Prototype board with *blue wires*
  - Envelope
    - http://www.scientificballoonsolutions.com
      - SBS-13 – 7.5' x 3', Approx. .5cu meter volume
  - Radios (10mW output each)
    - APRS – geofence frequency selection for WW coverage
    - WSPR – 14.0956Mhz with telemetry overlay
    - APRS and WSPR antennas (vertical dipoles)
  - Process
    - Fill to total payload/balloon weight PLUS 4-5grams (free-lift)
    - Bird could poop on it and it's coming down!!!
  - Launch
    - 7.5' long balloon with very small freelift
    - 20' tether above the tracker with 5mtr dipole below
  - YOU WANT TO DO THIS IN NO WIND!!!

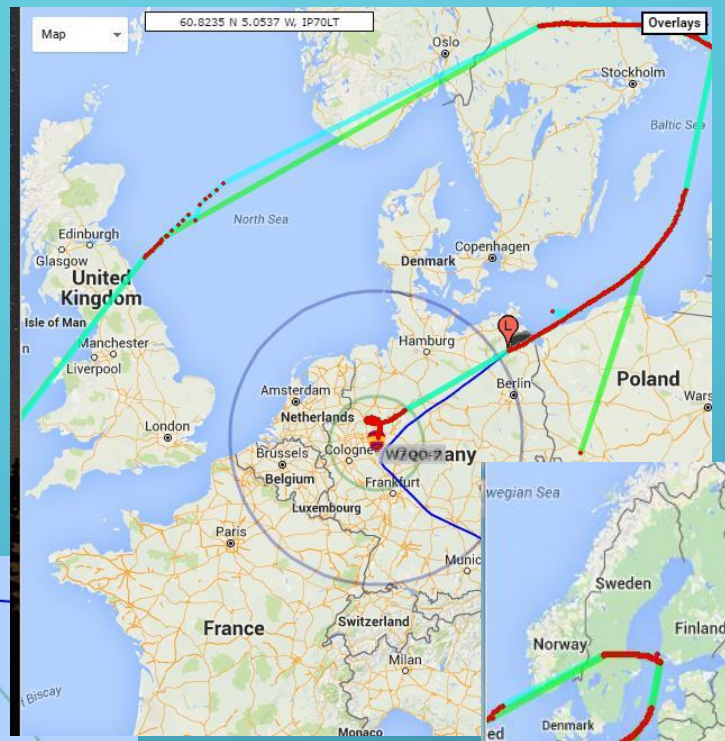


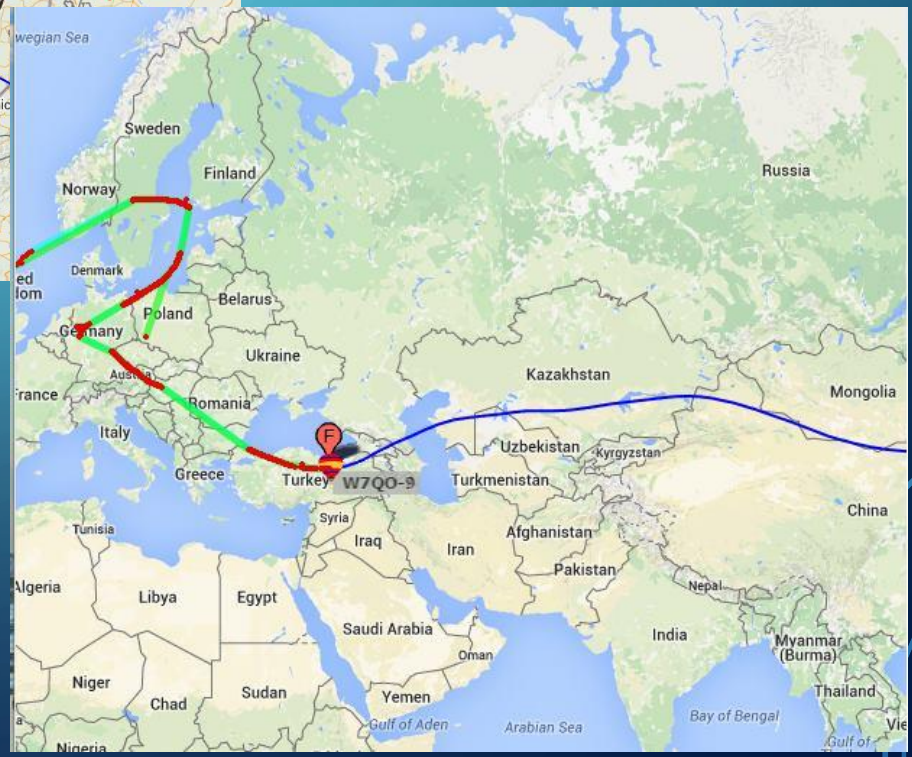


THE FIRST 15 DAYS – WHICH SEEMED LIKE FOREVER!

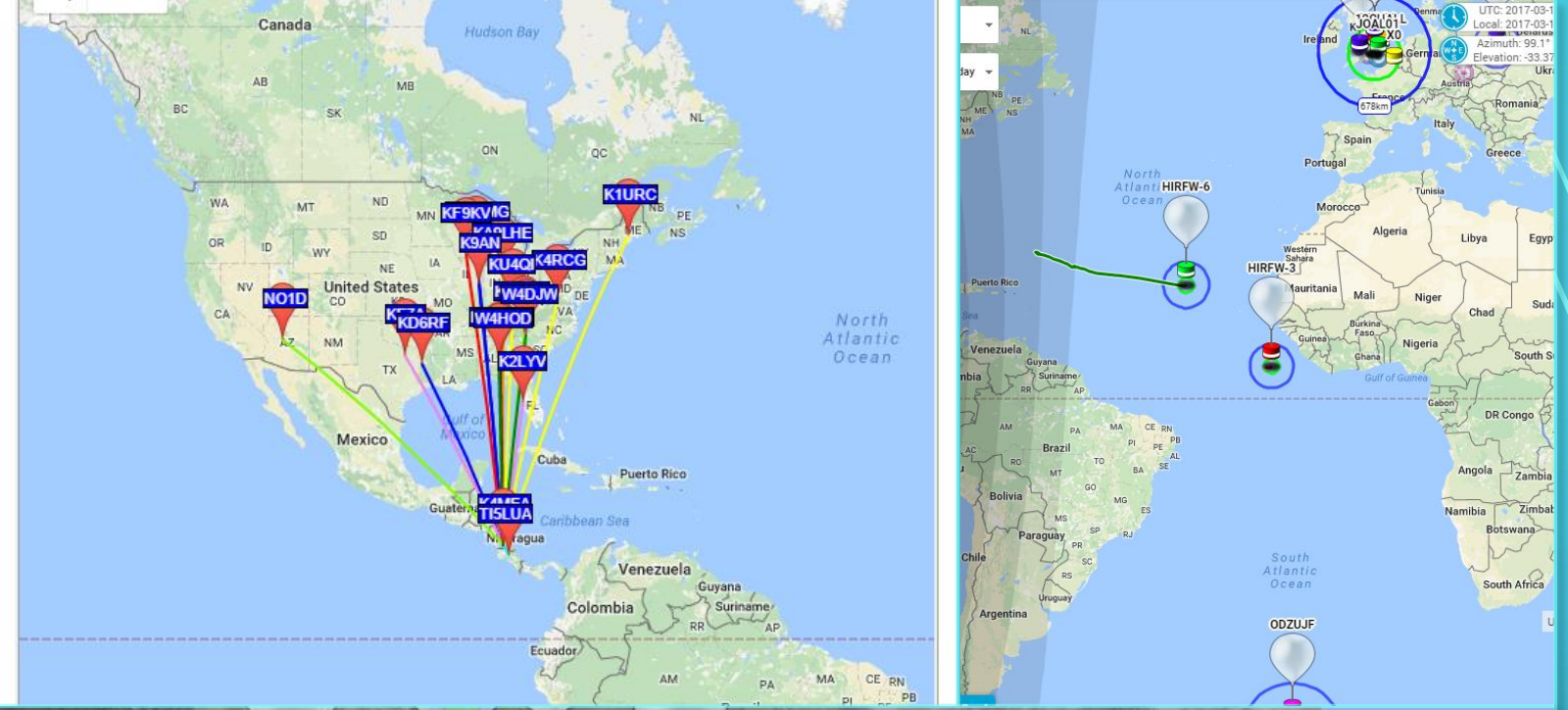






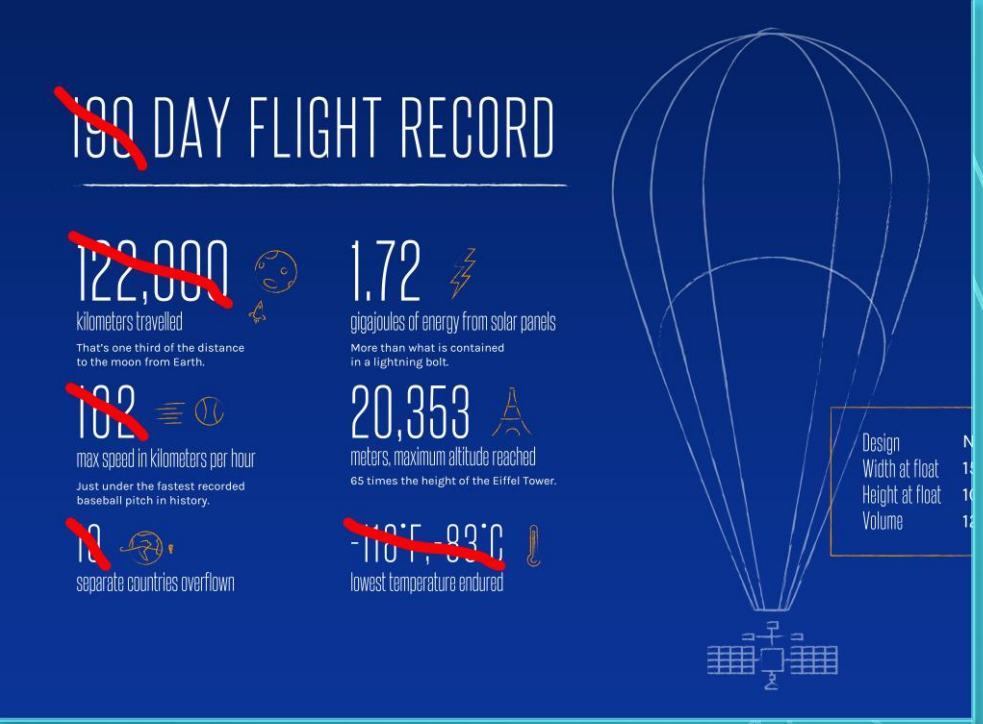


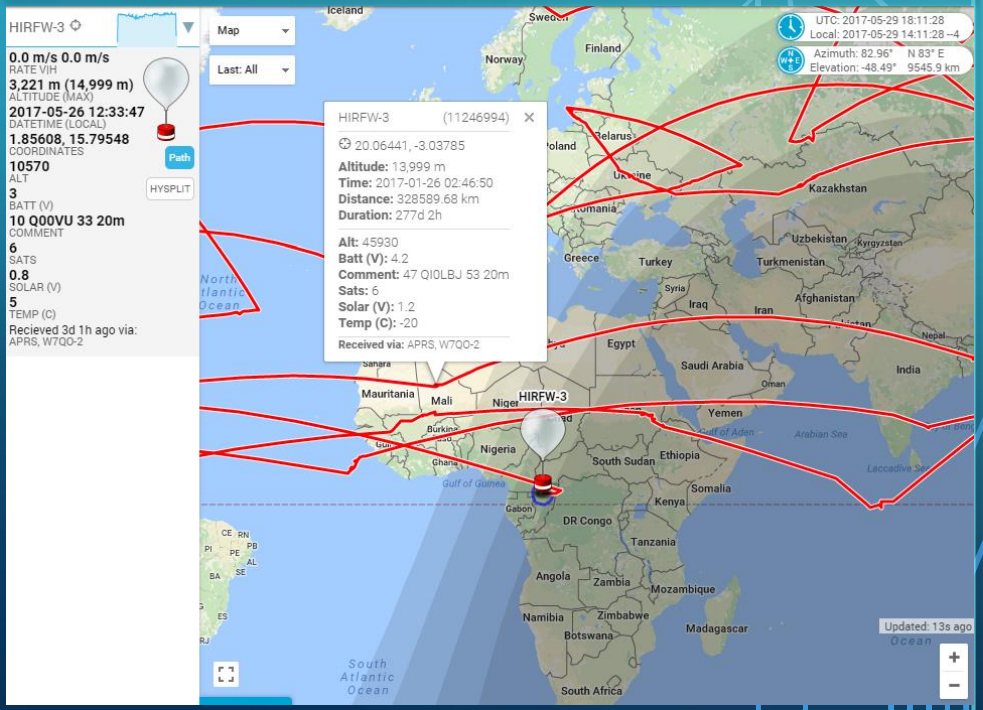
- 41500’ Float
- Almost 10 days to cross
- Supposed to take 4 to Greece
- 6 Digit Maidenhead works great
- WSPR WW Network made this possible



FROM 15 DAYS TO OVER 277!

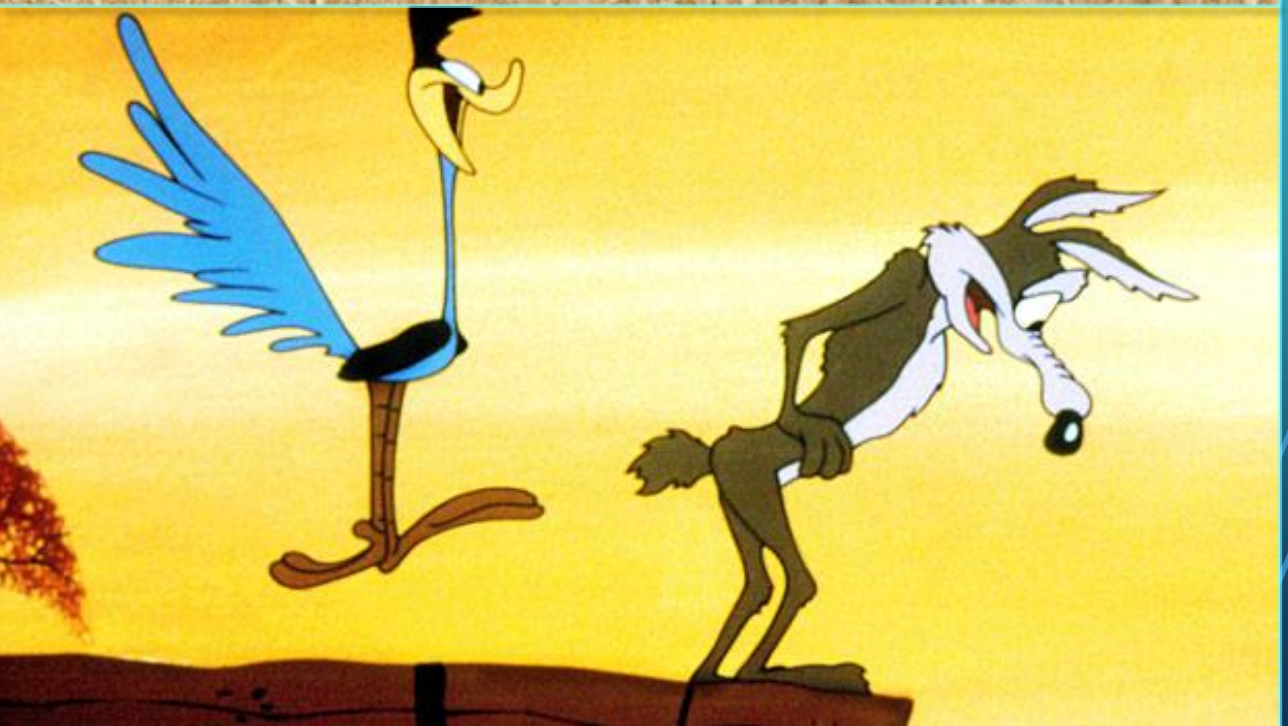
- HIRF(w)-3
  - Launched 8/22/2016
  - WSPR every 10 minutes (K4MEA)
  - APRS every 2 minutes (HIRF-3)
  - Altitude ~46000 ft., no signs of permeation!
  - Coming into spring in the Northern Hemisphere means challenges with storms





HELD AMATEUR RECORDS & BROKEN COMMERCIAL RECORDS

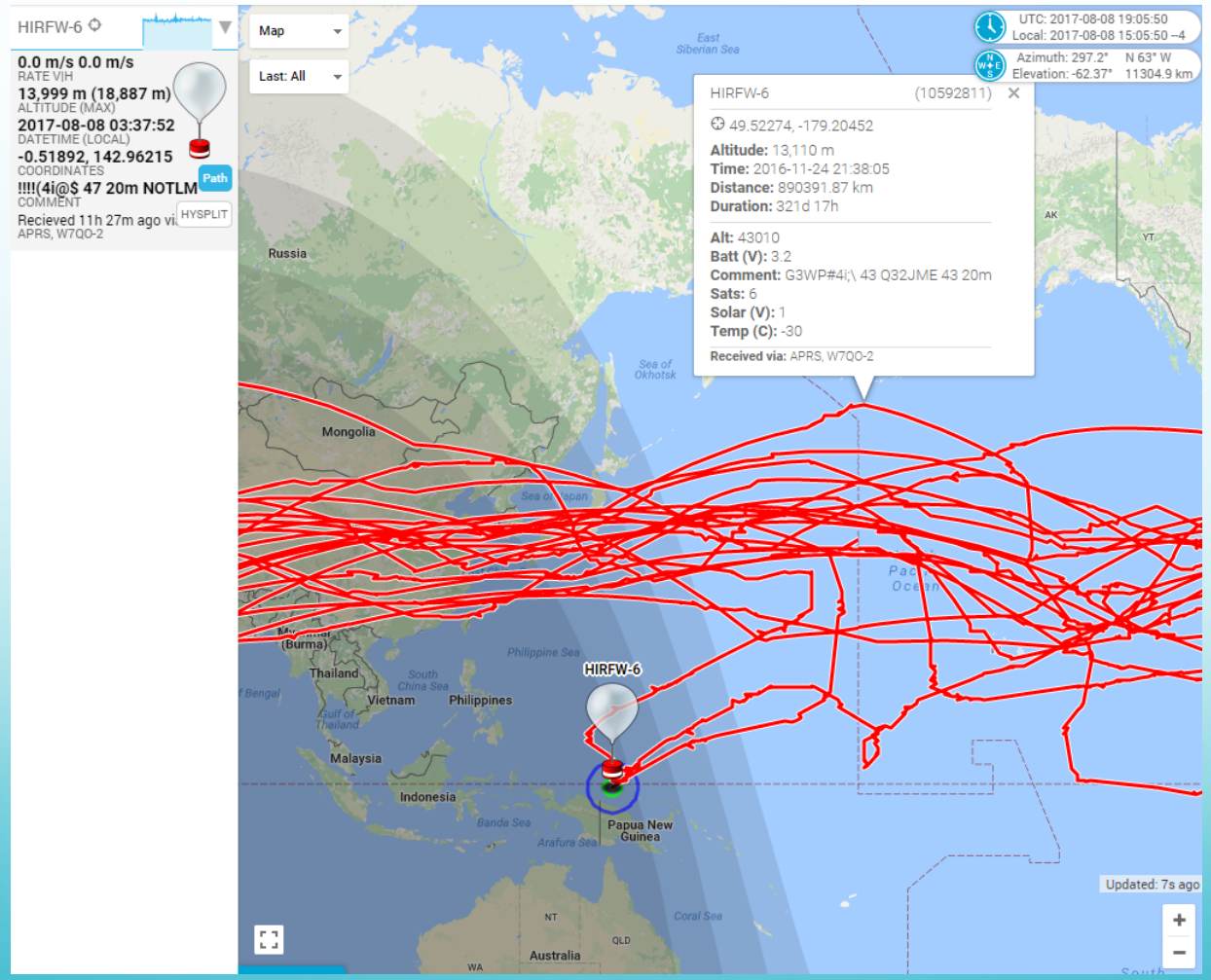
- Exceeded Google Loons records
  - 277+ days (just over 9 months)
  - 700,000+ Km distance travelled
  - > 200kts speed
  - < -83C temperature survival
  - Ultimate QRP - Multiple major continents in one WSPR transmission – from the middle of the Pacific Ocean!



MANAGING EXPECTATIONS

- This stuff is HARD!!!
  - It takes patience and perseverance
- First Flight may be a disaster, but don't give up
- Every flight reveals a learning (either positive or negative)
  - HIRF(w)-3 has a cold startup issue where it doesn't start every morning
- Explore new protocols/RF utilizations and how they can be learned and utilized (WSPR for moving objects)
- What is it about the $100 Bill?
  - Airplanes, Boats, Cars, you name it
  - Open your wallet, pull out a $100 bill, attach it to a string, attach string to Balloon and let it go!

WHEN IT ALL COMES TOGETHER – NEW RECORDS

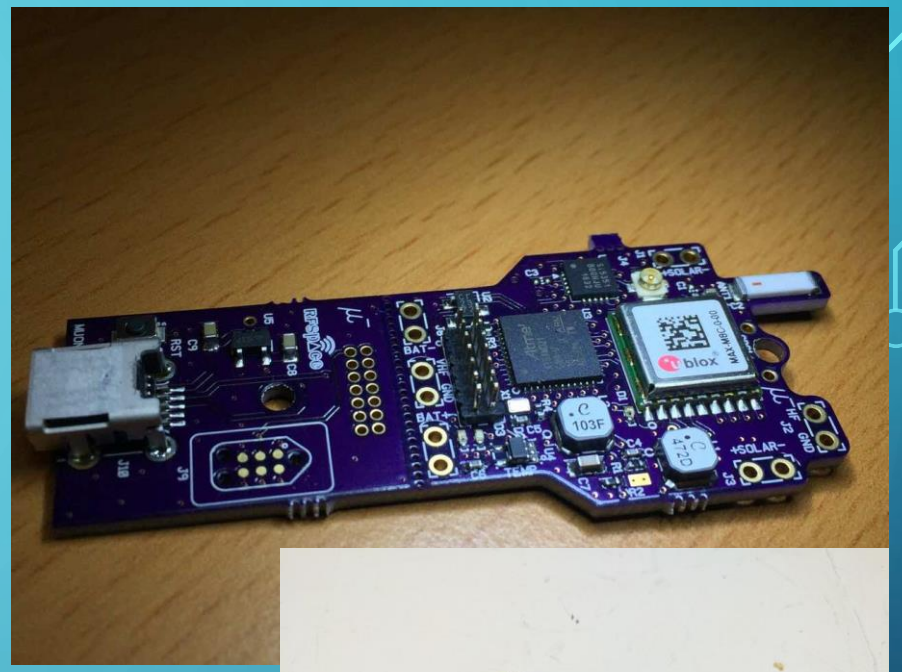


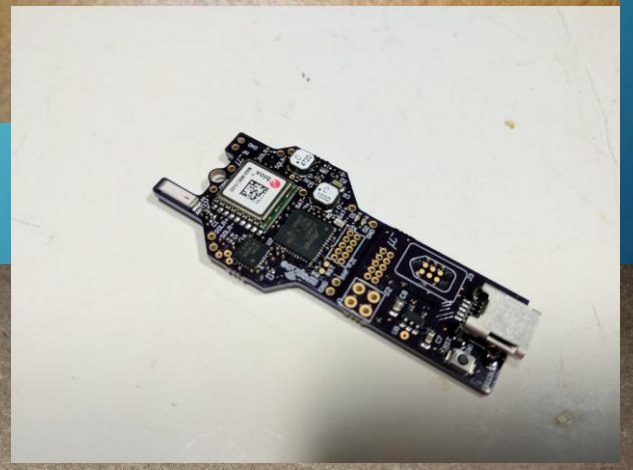
- HIRF(w)-6 (321+ days)
  - Launched 9/20/2016 (28 days behind -3)
  - WSPR every 10 minutes (K4JCW)
  - APRS every 2 minutes (HIRF-6)
  - Altitude ~46000 ft
- Successes – new records
  - Finished 19th Circumnavigation, started 20th
  - Traveled 890391+km – in effective distance it has traveled to the Moon and just returned!!!
  - WSPR and 20 mtrs proved a completely effective tracking method for daytime ops
  - Since launch has reported its position every day but 4!

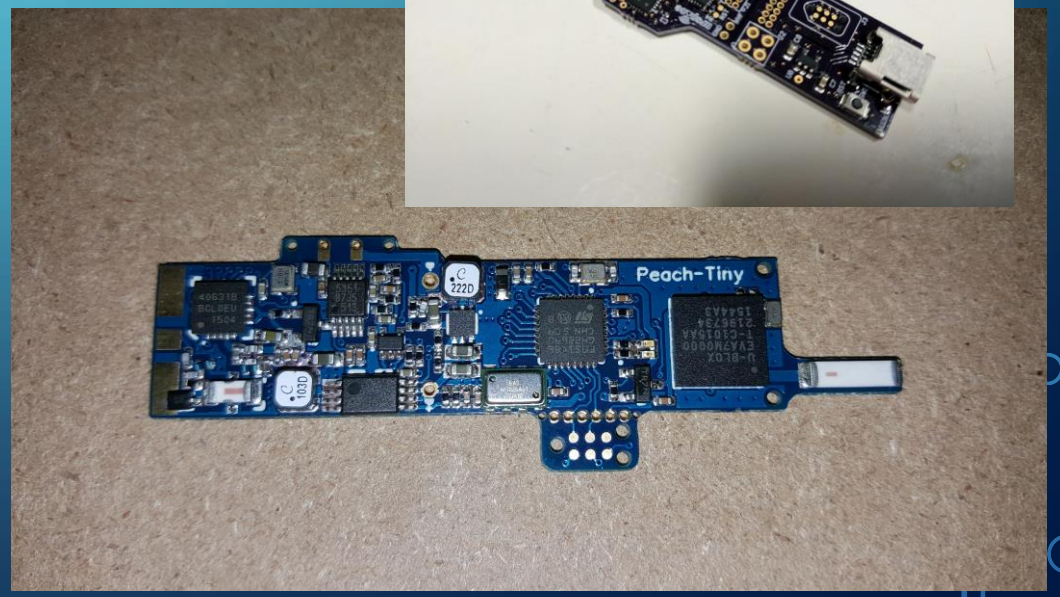
WHERE DOES IT GO FROM HERE

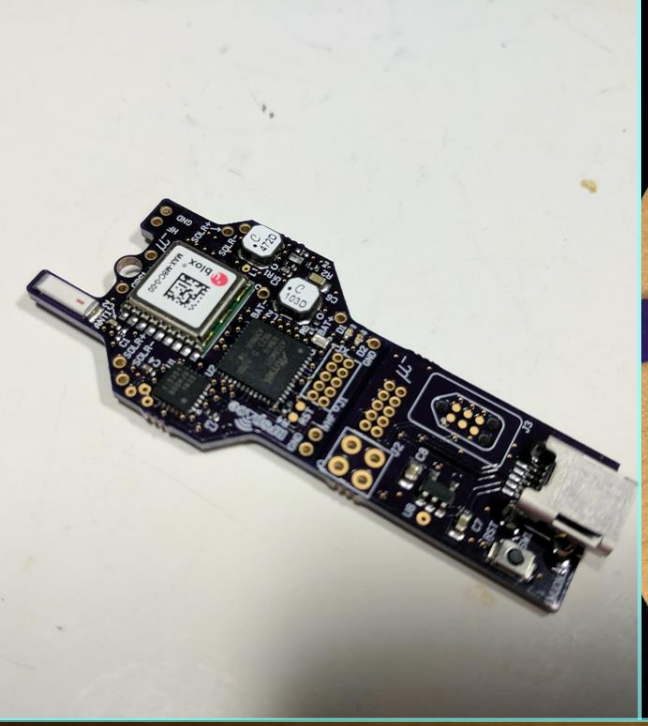
- The Sky is the Limit – Literally
- Improving areas
  - Envelope designs/material to get above aviation's 43k altitude
  - Battery chemistry to survive in -60C temps
  - Software enhancements to provide historical logs of the entire flight path
  - Other Top Secret stuff in the works ☺

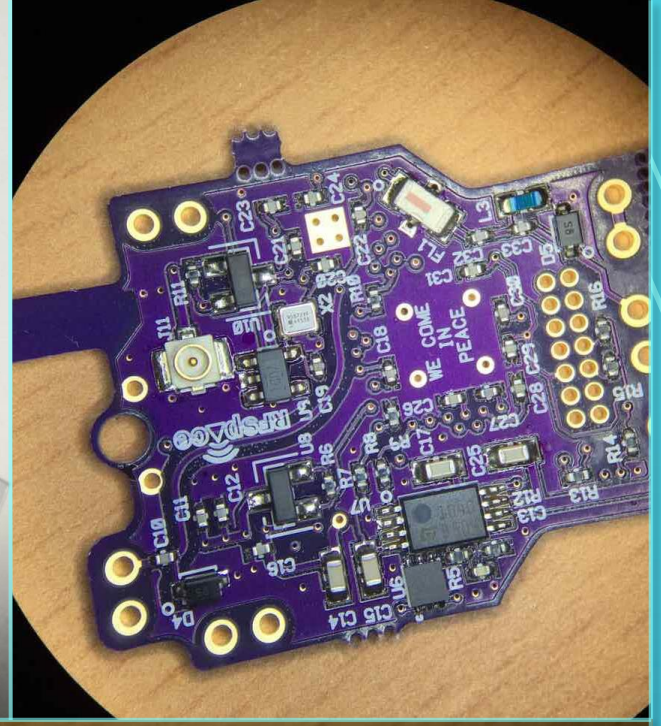
Final Board - ~1.5 grams

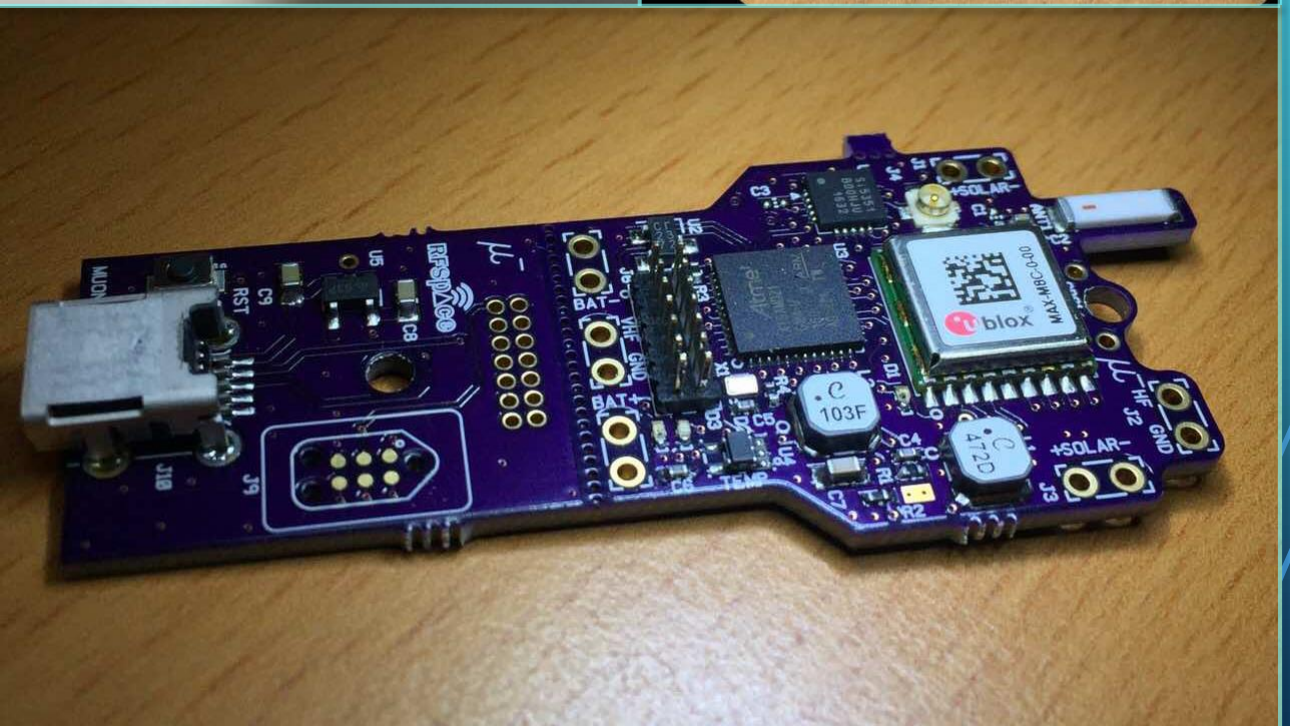












MEET MUON

THE QUARTER SIZED GLOBAL TRACKER

- Arduino Zero compatible w/bootloader
- 256K Flash, 32K ram, ARM M0+ ultra low power processor
- GPS with 1PPS, chip antenna and 50km altitude support
- Solar/Battery power supplies
- 2.5khz to 300Mhz frequency agile radio with VC input for true FM
- DAC or PWM modulation available to support WSPR and or APRS + others
- HF/VHF/custom/GPS external antenna connections
- Multiple programmable LEDs
- External header with GPIO, SPI, I2C, debug
- USB->Serial support built in
- Includes its own SWD/Arduino programing adapter with bench power supply

Coming Soon!

SKY'S THE LIMIT

2017 the year of the Solar Eclipse
August, maximum occlusion in the Eastern states

NEXT MILESTONE

- 1 year duration
- Night time operations

ULTIMATE RECORD

- Project Ghost
  - 744 days aloft for a commercial Balloon (NASA)

Share the fun

SIMPLE FORMULA FOR SUCCESS

- 36” Qualatex foil party balloon
- < 25gr Tracker with APRS
  - Solar capability if long duration attempt
  - Battery if short duration, but with overnight capability
  - Use .013” nickel plated Ernie Ball guitar string for APRS antenna
- Fill Balloon to 3grams of freelift
  - He or H2, H2 will give you ~+1km in float altitude
- 100” tether between balloon and payload
- Expect 24-28k feet and multiple day reporting
- Double balloons can get you to 30k ft or close to 10km
  - Each balloon lifts ½ payload + ½ freelift
- Remember to include all the tape, string, etc. weights

ADDITIONAL RESOURCES

- Large group in the UK, very active, with prediction, tracking, open and public information
  - https://ukhas.org.uk – WIKI, general information
  - https://tracker.habhub.org – online tracker
  - https://habhub.org – prediction, SSDV images, database information
- APRS.fi online – http://aprs.fi
- Amateur Radio High Altitude Ballooning – http://arhab.org
- Freenode IRC
  - #highaltitude
  - #habhub
- Great Plains Super Launch – once a year – http://superlaunch.org