Amateur Radio High-Altitude Ballooning

A look at the radio amateur’s budget AMSAT program

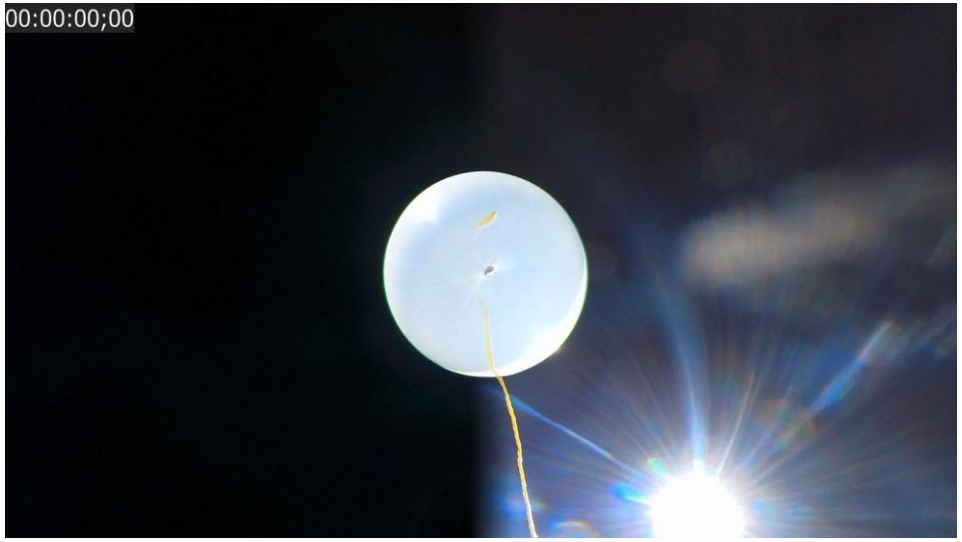
Andrew Koenig – KE5GDB

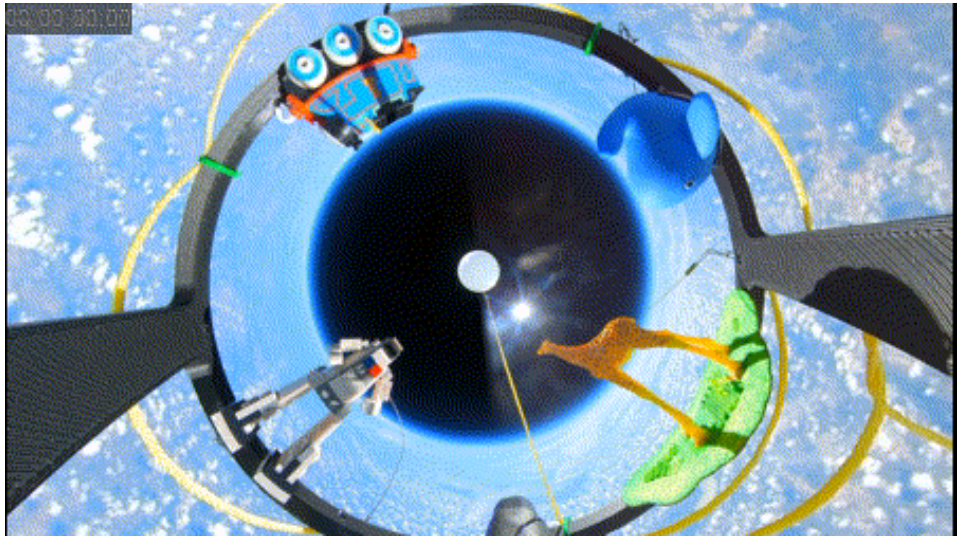
- Licensed in 2005 in Houston TX
- Live in Richardson TX
- UT Dallas graduate
- Have participated and launched with several groups:
  - South Texas Balloon Launch Team (“BLT”)
  - Plano Amateur Radio Klub – PARKBalloon
  - Richardson Wireless Klub – “Richardson Area Balloonatics”
  - Various other groups

Typical Goals of High-Altitude Balloons

- Experimentation
  - New modes, protocols
  - Hardware design
  - Pushing the limits of “COTS”
- Communication
  - Repeaters
- Imaging
  - Cameras

- What can be accomplished from the edge of space in 2.5 hours?





Standard Payloads

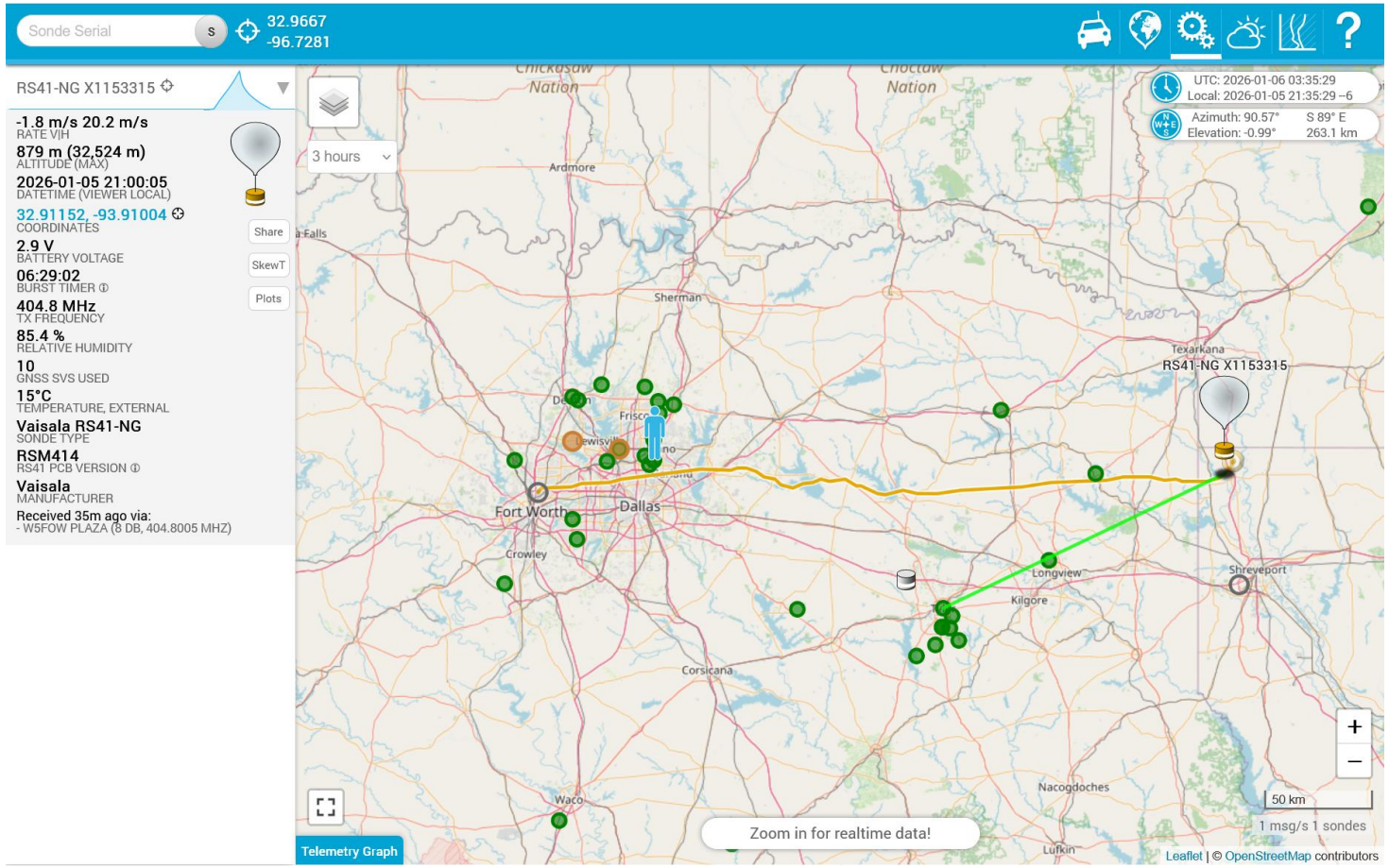
- Trackers
  - Vaisala RS41 Radiosonde
- Cameras
  - Wenet
  - Insta360 X5
- Repeater
  - DMR: Hytera PD982
  - Analog: Yaesu FT-530
- Balloon Neck
  - Raspberry Pi Pico W + RAB Board

STM32 Dev Boards falling from the sky

- **Vaisala RS41 Radiosonde**
  - UHF transmitter + GPS
- Launched at NWS Ft. Worth @ 0000z and 1200z
- Tracked via www.sondehub.org
- Recovered by enthusiasts
- Reprogrammed with ham-friendly firmware
- Launched again by hams

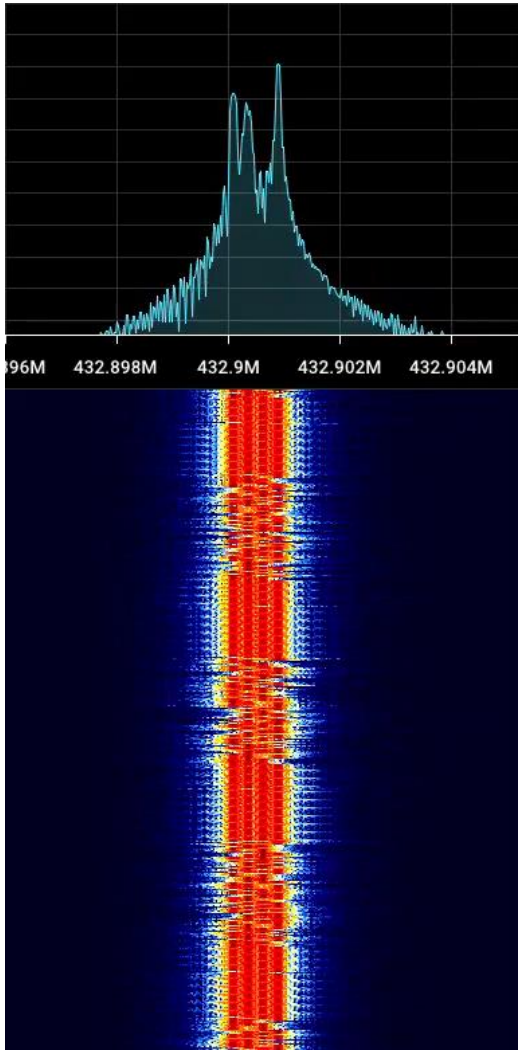
Sondehub + Chasing

- Receivers:
  - Pi + RTL-SDR
    - Software Radiosonde_auto_rx
  - LilyGo TTGo
    - Firmware rdz_ttgo_sonde
- Chasing:
  - Enable chase mode!
  - Don’t get shot



Better than APRS: Horus Binary

- Available in RS41ng – Ham-friendly firmware for radiosondes
- Technical Details:
  - 100-baud 4-FSK
  - 32-byte payload
    - Lat, Lon, DateTime, Alt, Speed, Sats, Temp, Voltage, +9 bytes
  - 3.3 seconds per packet
  - ~1KHz bandwidth
  - Golay FEC
- Benefits:
  - Much higher noise immunity
  - >20dB advantage over 1200 baud AFSK (i.e., APRS)
  - Can be received with wet string
- Disadvantages:
  - Requires UHF-capable SSB radio
  - Fewer ground stations



Receiving Horus Binary v2

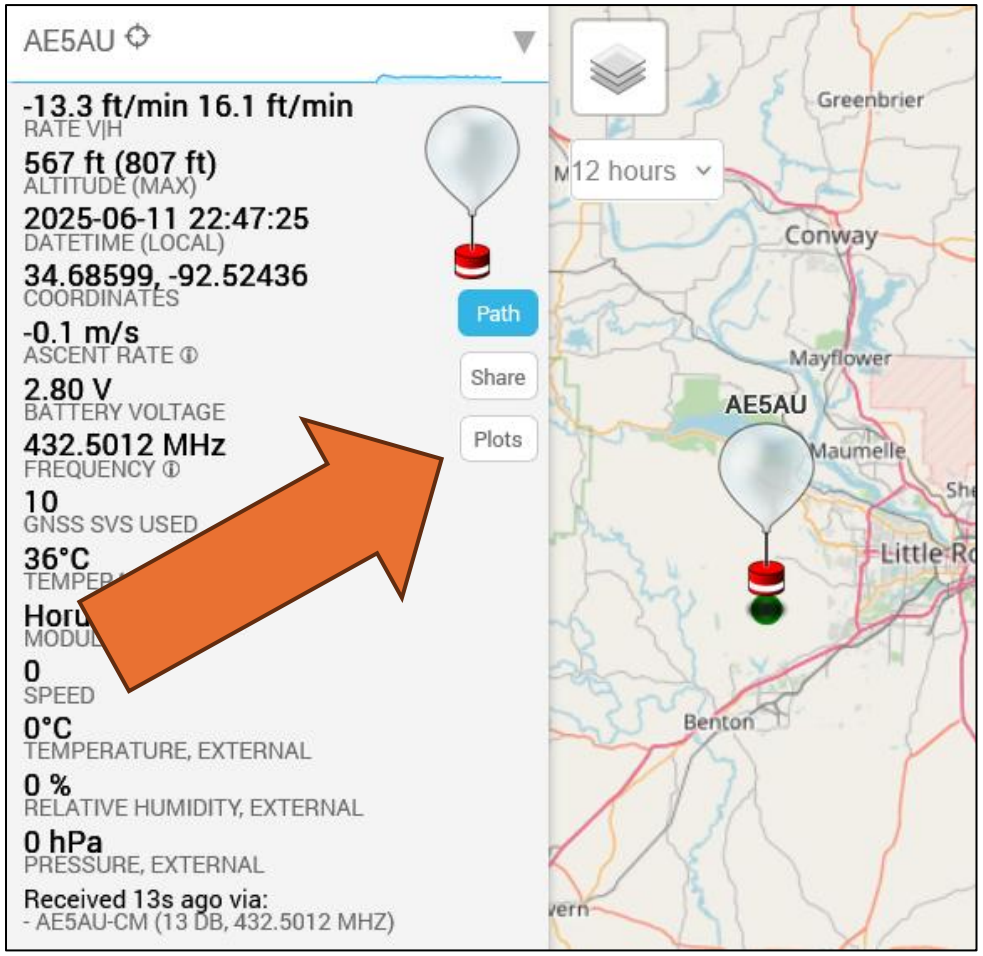
- 432MHz Upper Sideband
  - RTL-SDR, FT-817, IC-9700, many more
  - Quansheng UV-K5 (6)
- Web Browser with RX audio or RTL-SDR
  - *Easiest!*
  - http://horus.sondehub.org/
- Horus GUI
  - Supports audio input (IC-9700, IC-705, Signalink, soundcard)
  - Supports UDP audio (GQRX, SDR++)
  - Rotator control – rotctld
- Horusdemodlib
  - Headless Pi + RTL-SDR

Horus GUI decoding RS41

SondeHub Amateur

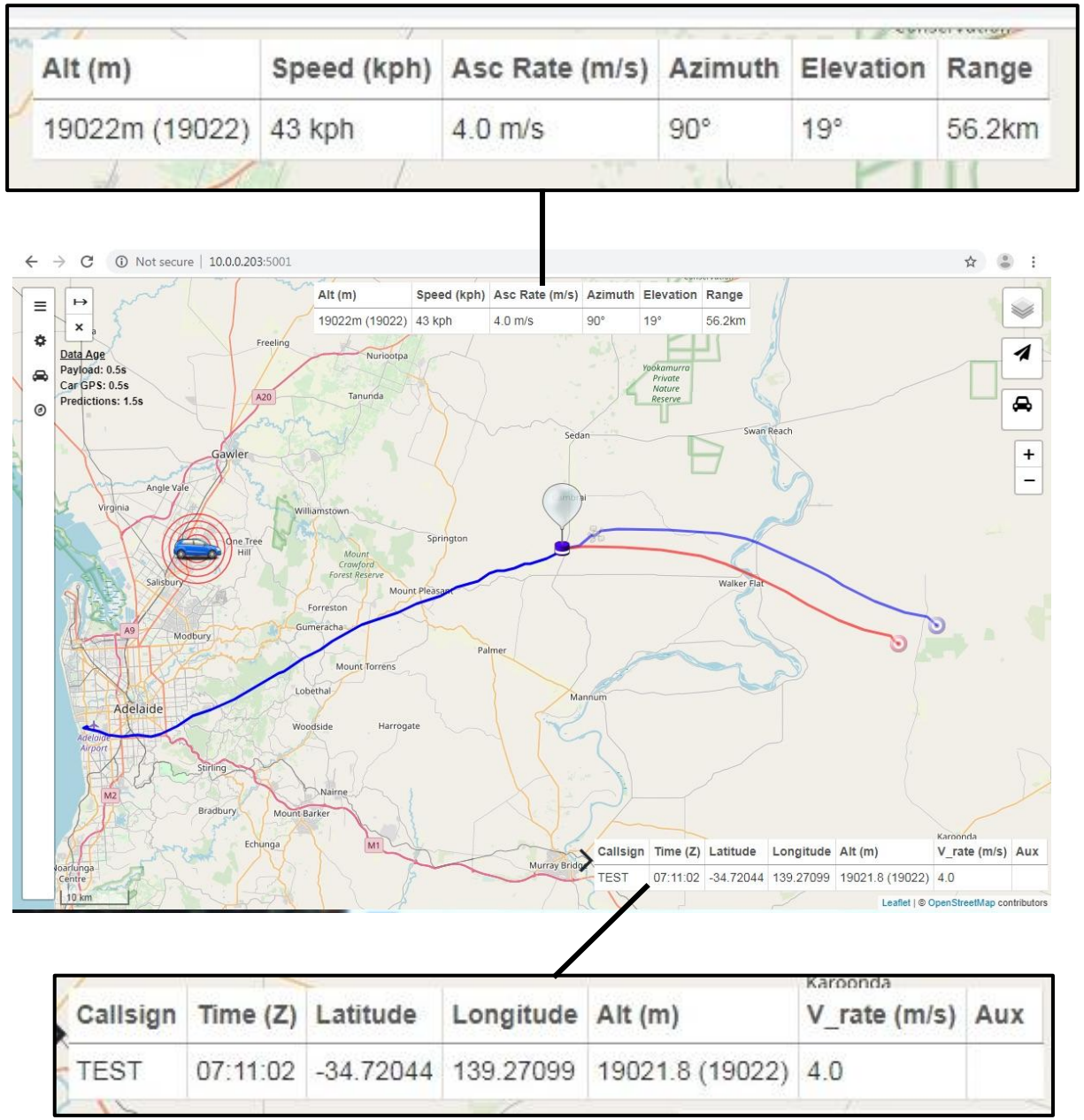
- Designed specifically for HAB use
- Mapping Interface
- Chase Car Support
  - Direct upload, “SHUB” in APRS path
- Robust Telemetry Display
- Real-time landing predictions
- Automatic APRS ingest (balloon icon)
  https://amateur.sondehub.org/

- SondeHub Plots Example



Chasemapper

- Local mapping interface
- Collects balloon packets via UDP listener
- Chase car position uploader
- Real-time offline predictions
  - Burst now
  - Burst at target altitude
- Landing timer after burst
- Can use locally cached maps



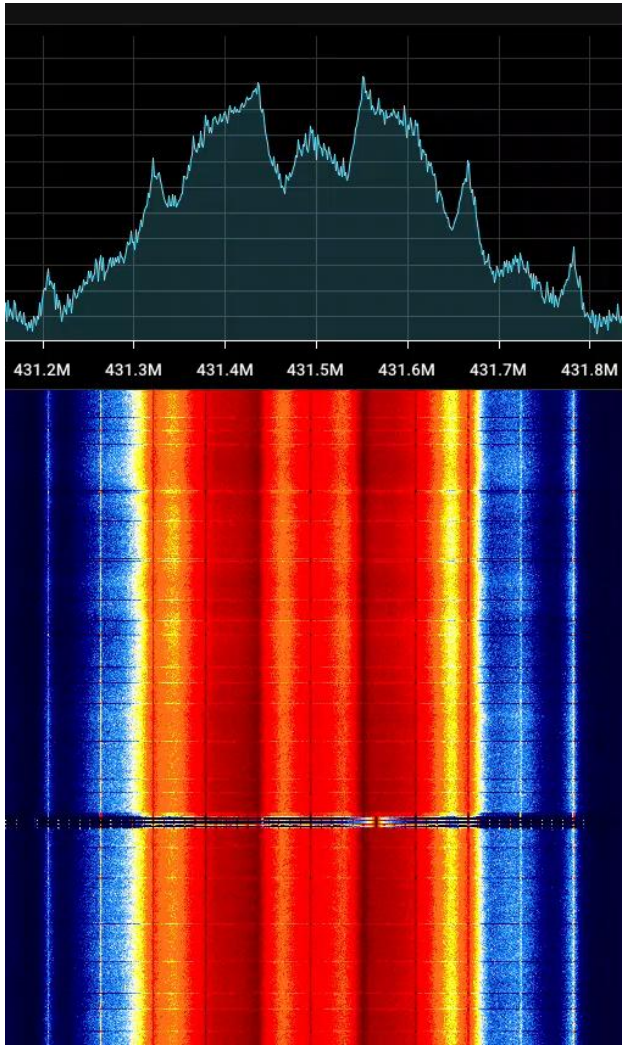
Installing Chasemapper

- Runs in Docker container
- Easy to install on most operating systems
- Runs headless – ideal for Pi
  - Works well with display too!

- Display on dash with tablet (web browser)

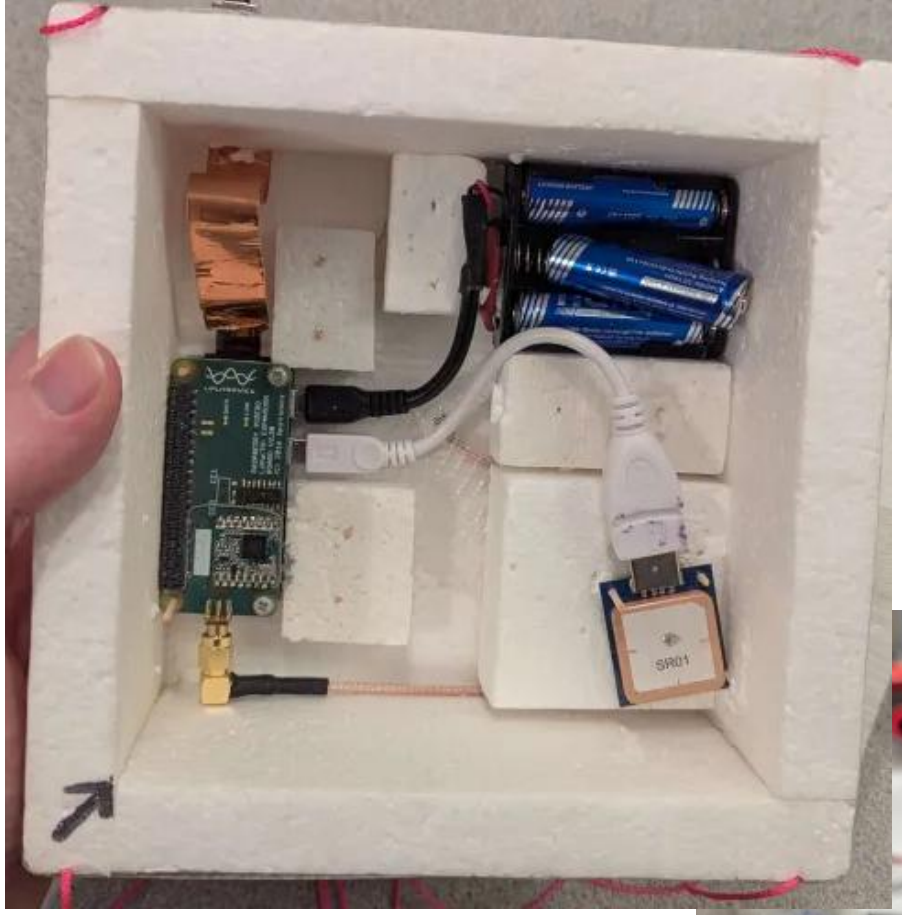
Wenet – end-to-end Image Transmission

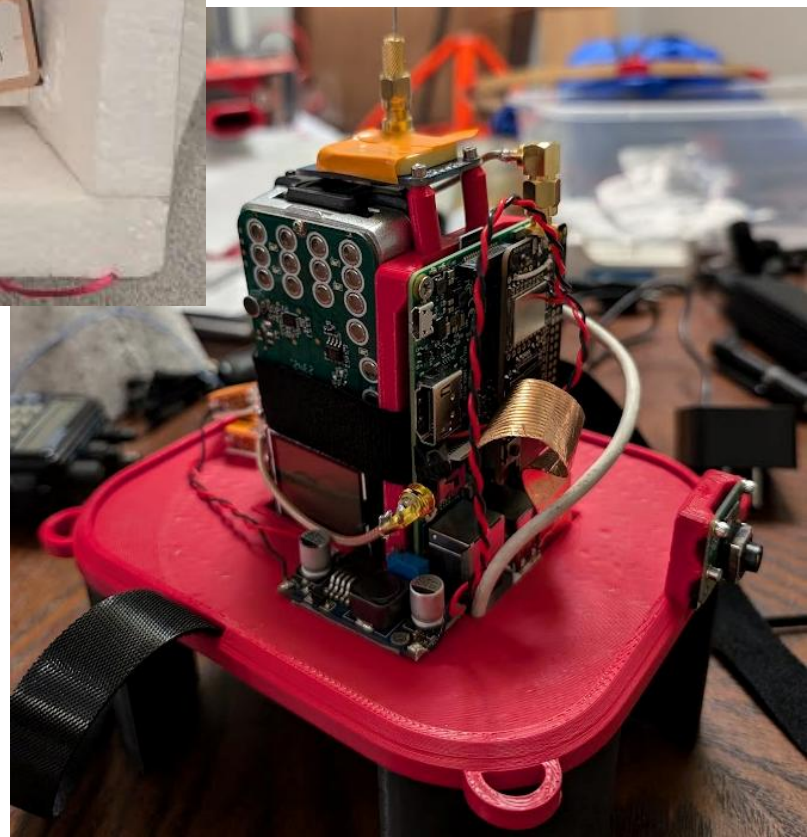
- Collects images via Pi Camera
- Resizes, adds overlays, compresses
- Transmits via 96 kbaud link
  - Uses RFM96W/RFM98W LoRa Radio
  - 2-FSK, not LoRa (just uses radio)
  - Direct, async mode
  - LDPC for ~6dB coding gain
  - ~300KHz Bandwidth



Wenet – Building Your Transmitter

- Raspberry Pi 3 or newer
  - Pi Zero 2W works great!
- RFM96W Pi HAT
  - Adafruit - $30
- Pi Camera
- U-Blox USB GPS
  - Shield camera cable for best success
- KE5GDB Method:
  - Faucet Cover
  - 3D-Printed base





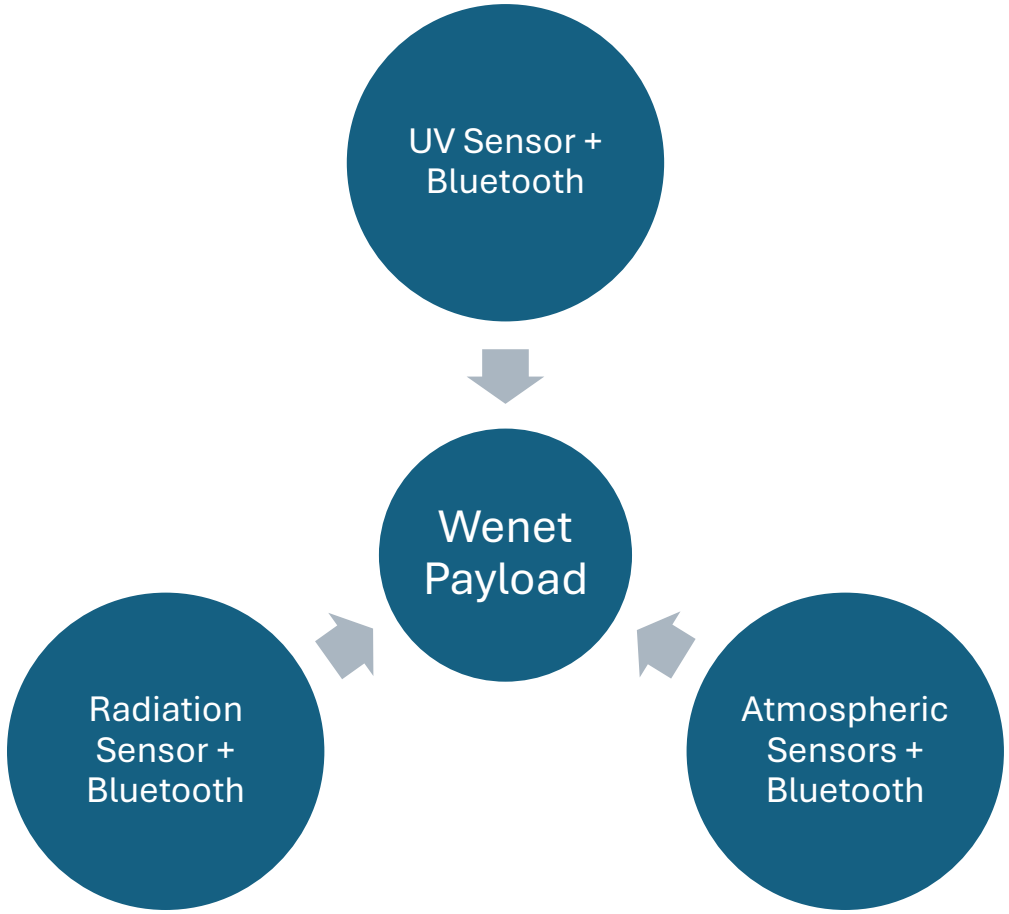
Wenet – Building Your Receiver

- Raspberry Pi 3 or newer
- RTL-SDR + Pre-amp
  - Uputronics 434MHz recommended
- Need antenna gain
  - Turnstile antenna on chase vehicle
  - Tracking az/el station (if available)
- Install Wenet docker image
- Upload to ssdv.habhub.org

- New method: wenet.sondehub.org
  - RTL-SDR and Chrome – Genius implementation by VK3FUR

Wenet – Additional Features

- GPS data to SondeHub Amateur
- Image data to ssdv.habhub.org
- Image composed of many packets
  - Incomplete images can be reassembled
- Telemetry Aggregation
  - UDP listener on payload
  - Downlinks over high-speed link
  - BLE (demonstrated!)
  - Pi Pico W + Sensors
  - Perfect for student payloads!



KE5GIDB image 78

2024-09-21 16:30:30

Received: 1305 packets, 0+ missing
Receivers: K5UTD, KE5GIDB-SatRig

“Richardson Balloonatics” docker-compose.yml

pi@GDBChasePi: ~/balloonatics/ground_station

```
CONTAINER ID   NAME                                    CPU %
854c726357b9   ground_station-horus-432750-1           3.68%
ff1e03cbf202   ground_station-horus-432650-1           3.62%
8f34240eccef   ground_station-horus-432550-1           3.72%
a6971c6b3d23   ground_station-horus-432625-1           3.86%
74a3f7b2d7c5   ground_station-horus-432600-1           3.74%
5a4ea20c4ddd   ground_station-chasemapper-1            0.49%
6bfb0d51a8f7   ground_station-horus-432800-1           3.85%
c870c28abfeb   ground_station-maptilesdownloader-1     0.02%
071242af803f   ground_station-horus-432850-1           3.77%
d3d685738078   ground_station-horus-432700-1           3.93%
f9459f17e0a7   ground_station-horus-432675-1           3.64%
70ef4ad9a7cd   ground_station-wenet-431500-1           41.80%
ecd81b7190db   ka9q-radio                              67.45%
f4338b21f6da   ground_station-horus-432775-1           3.76%
650c30434595   ground_station-horus-433000-1           3.67%
abbe323601f8   ground_station-horus-432900-1           3.86%
cf1f8b0d9f54   ground_station-horus-432725-1           3.64%
296c3e1d814f   ground_station-horus-432950-1           4.85%
```

- Single RTL-SDR @ 2MHz bandwidth
- ka9q-radio – multi-slice receiver
  - Absolute genius by KA9Q
- Wenet decoder
- Horus Binary decoders (15 for GPSL)
- Chasemapper
- Maptilesdownloader

- www.github.com/k5rwk/balloonatics/

Repeater – DMR Single Frequency Repeater

- Hytera PD982 HT
  - With $100 “SFR” option
- Simplex for user
- Listens on TS1, retransmits on TS2
- Seamless for users

- Program your radio:
  - 441.0MHz
  - CC1
  - TS1
  - TG99

Repeater – Analog FM

- Yaesu FT-530
- You transmit:
  - 147.435MHz
  - PL67.0
- You receive:
  - 446.0MHz
  - No PL

Story Time

- RAB-2 https://photos.app.goo.gl/zqf6Vc6YXz5ua7Dj6
- GPSL https://photos.app.goo.gl/EqUyTtLfYpnjETnR9
- RAB-8 https://youtu.be/isOqnn-r--Y

Get involved!

- Attend launches
- Balloonatics Meetings
  - Every other Sunday @ 2:00PM
    - Next 3/29
  - Dubs Tea ‘n Eats in Plano
- Build payloads!
  - Have an idea? Let’s fly it!

- https://k5rwk.org/balloons