High Data Rate HAB communications

Capitol Technology University
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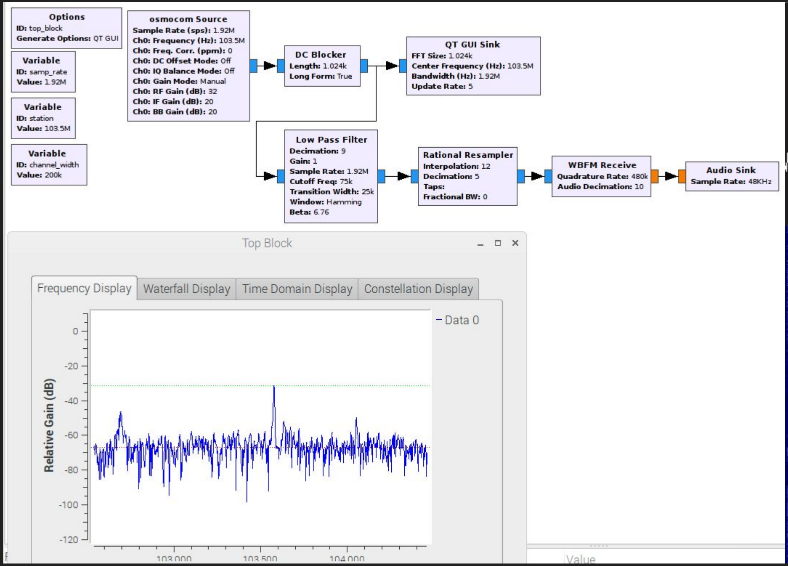
Is it possible to **increase data rates** for High-Altitude Balloon (HAB) **by 10x** or better for direct communications?

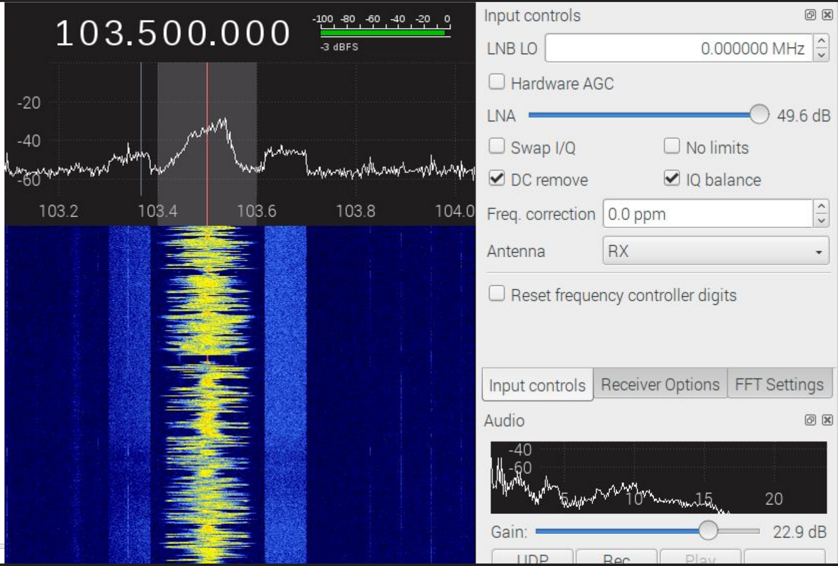
- Most HAB projects rely on payload recovery to access captured data
  - Payloads have been lost or destroyed
  - Difficult to see data and change mission parameters in real time
- Packet Radio
  - 1200-9600 bit/s -- slower than your average 1990s modem
  - 2 MB photo; about ½ hour (without overhead)
- The Rise of Software-Defined Radio (SDR)
  - Inexpensive
  - Programmable
- Use inexpensive off-the-shelf components

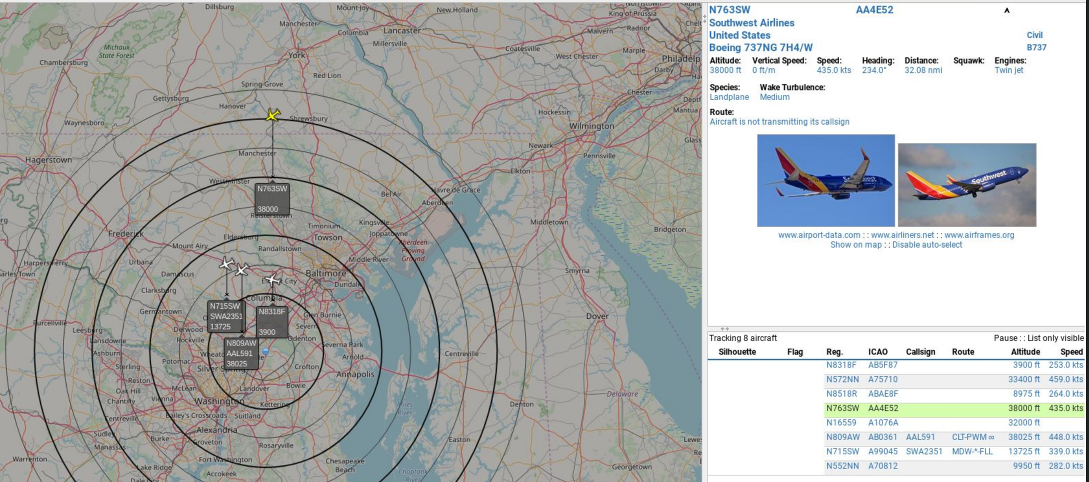
Main Components

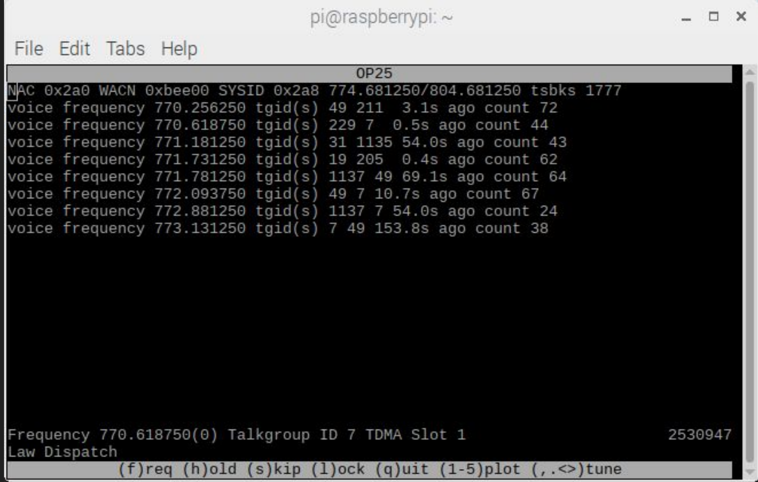
- Raspberry Pi
- Software-Defined Radios (SDRs)
- Antennas

Basic Radio Skills





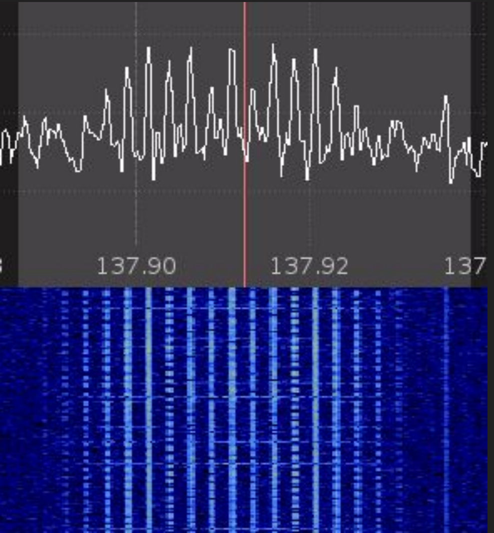




Long-Distance Application: NOAA Weather Satellites

- Earth Images sent from satellites (500+ miles up)
- Recording Process
    - Record digitized Audio using GQRX
    - Decode Audio using an APT decoder

Signal



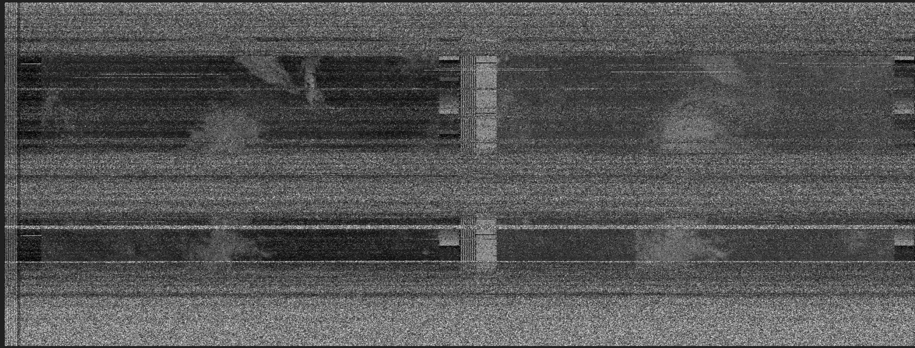
Test Rig 1

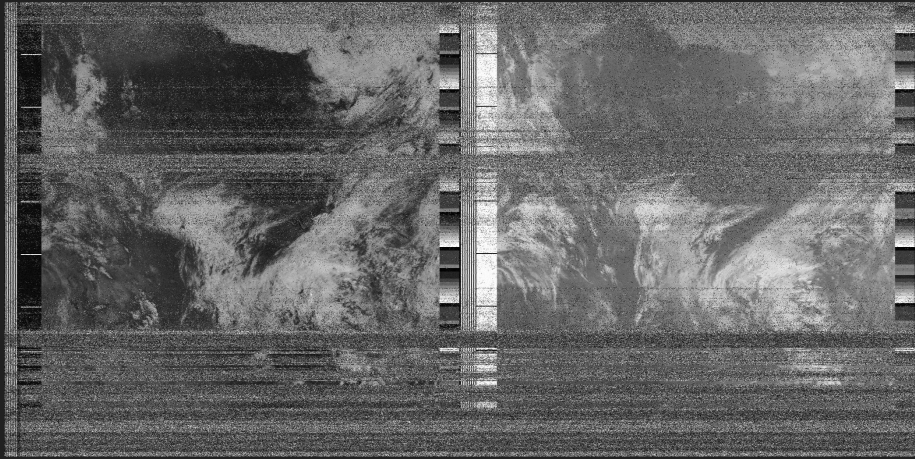
Test Rig 2

Results:
NOAA Weather Satellites

For best reception

- Sunny and Clear
- Antenna -- high and clear area
- Antenna -- use highest gain*
- Greater Elevation Angle (15° minimum)
- Slightly higher recording bandwidth



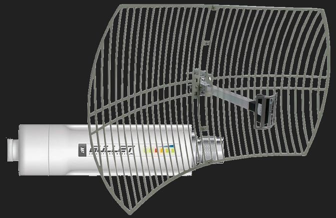


Frederick Overlook Test: 6.6 mi

- Goal: Simulate communication from 4-7 miles
- “Link budget” (-70 dBm ideal)
- Able to “see” hotspot (-88 dBm best)
- 10+ dBm under anticipated
    - Several attributing factors

- Result: Unlicensed clear line-of-sight communication possible from a few miles

Sugarloaf Mountain Test: 15 mi



- Goal: Simulate communication from 10-15 miles
- “Link budget” (-72 dBm ideal)
- Able to connect (-84dBm best)
  - Able to ping once
- 10+ dBm under anticipated
  - Unsolved and new attributing factors

- Result: Unlicensed clear line-of-sight communication possible from 15 miles

Test Analysis

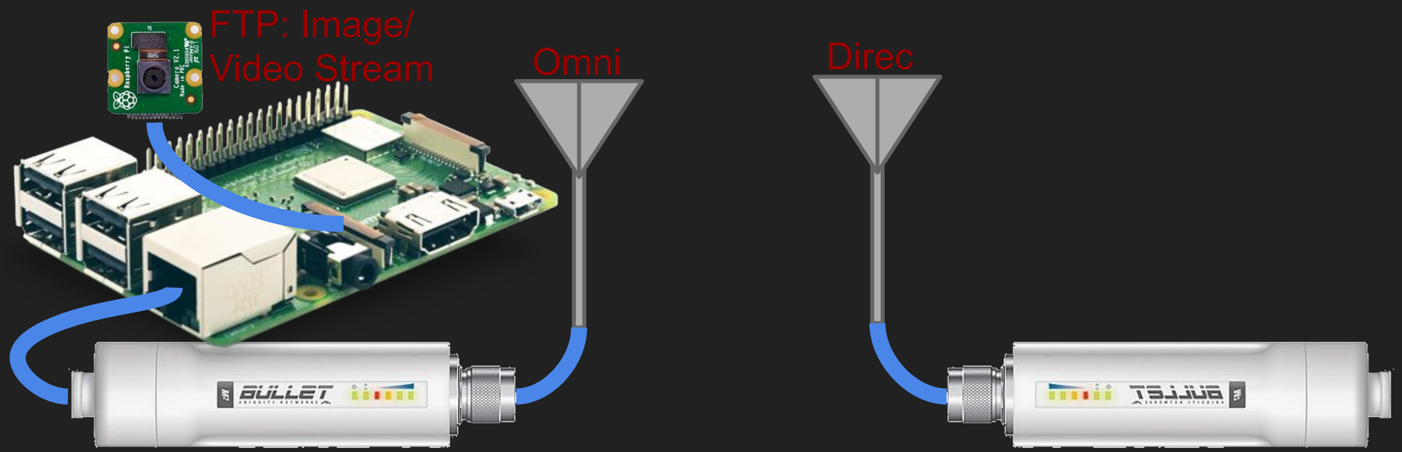
Sources of Signal Loss

- Various Antenna issues
  - Dish missing secondary reflector
  - Cantenna poorly made
- SDRs underpowered (1W - 30 dBm legal)
  - Alfa: 21 dBm max; Ubiquiti: 25 dBm max
- Obstructions (Vegetation)
- Antenna adapter and coax cable loss

Inside of “Cantenna”

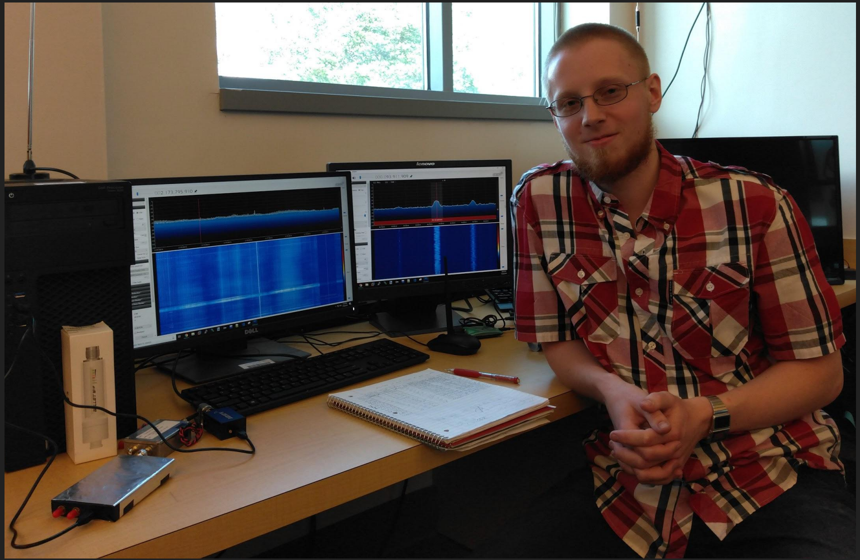
Future Work

- Improve Antenna Hardware
- Use amplifiers
- Payload Stabilization
  - Kite-Rods -- increase moment of inertia
  - Swivels -- isolate twisting energy better
- Design/Launch Payload



Personal Experience

- Learned and gained experience in desired field
- Surprised to get communication at great distances
- Earned amateur radio license



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Special Thanks:
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Shawn Gastello