## High Data Rate HAB communications

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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)

BRINKEL

AIRSPY

-

• Antennas

#### Basic Radio Skills





N763SW Southwest Airlines		/	AA4E52			A Civil	
Boeing 7	37NG 7H4/W					B737	
Altitude: 38000 ft	Vertical Speed: 0 ft/m	Speed: 435.0 kts	Heading: 234.0*	Distance: 32.08 nmi	Squawk:	Engines: Twin jet	
Species: Landplane	Wake Turbule Medium	nce:					
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voice	frequency	770.256250	tgid(s)	49 211 3.1s ago count 72					
voice	frequency	770.618750	tgid(s)	229 7 0.5s ago count 44					
voice	frequency	771.181250	tgid(s)	31 1135 54.0s ago count 43					
voice	frequency	771.731250	tgid(s)	19 205 0.4s ago count 62					
voice	frequency	771.781250	tgid(s)	1137 49 69.1s ago count 64					
voice	frequency	772.093750	tgid(s)	49 7 10.7s ago count 67					
voice	frequency	772.881250	tgid(s)	1137 7 54.0s ago count 24					
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Law Dispatch (f)req (h)old (s)kip (l)ock (q)uit (1-5)plot (,.⇔)tune

#### 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





#### 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





- "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

![](_page_10_Picture_4.jpeg)

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> Special Thanks: Professor Ed Sigler Shawn Gastello