

# FoxTLM

A Software Demodulator and  
Telemetry Display Program for the  
Fox-1 Satellite



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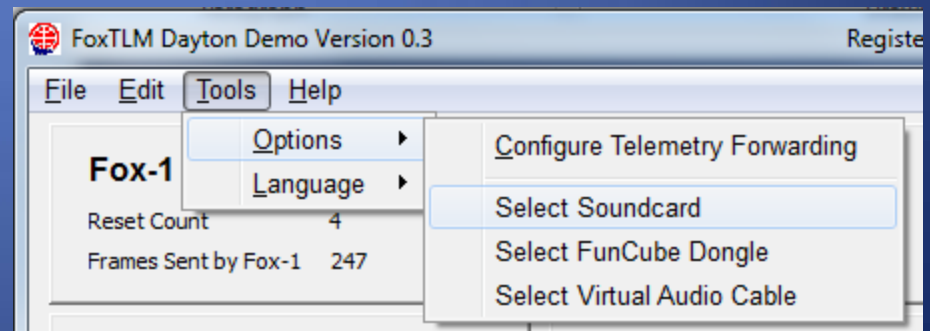
KA2UPW/5

# Fox-1 Telemetry Background

- Fox-1 will send low speed always-on telemetry at the same time and same frequency as voice FM transponder whenever uplink signals are heard
- Voice and telemetry all of the time (win-win)
- Telemetry data sent as audio below 300 Hertz
- “Sub-audible telemetry” where repeater sub-audible tones would normally be found
- GMSK modulation at about 80-100 baud
- After five minutes with no uplink signals, Fox-1 will transmit one telemetry frame

# Goals and Objectives

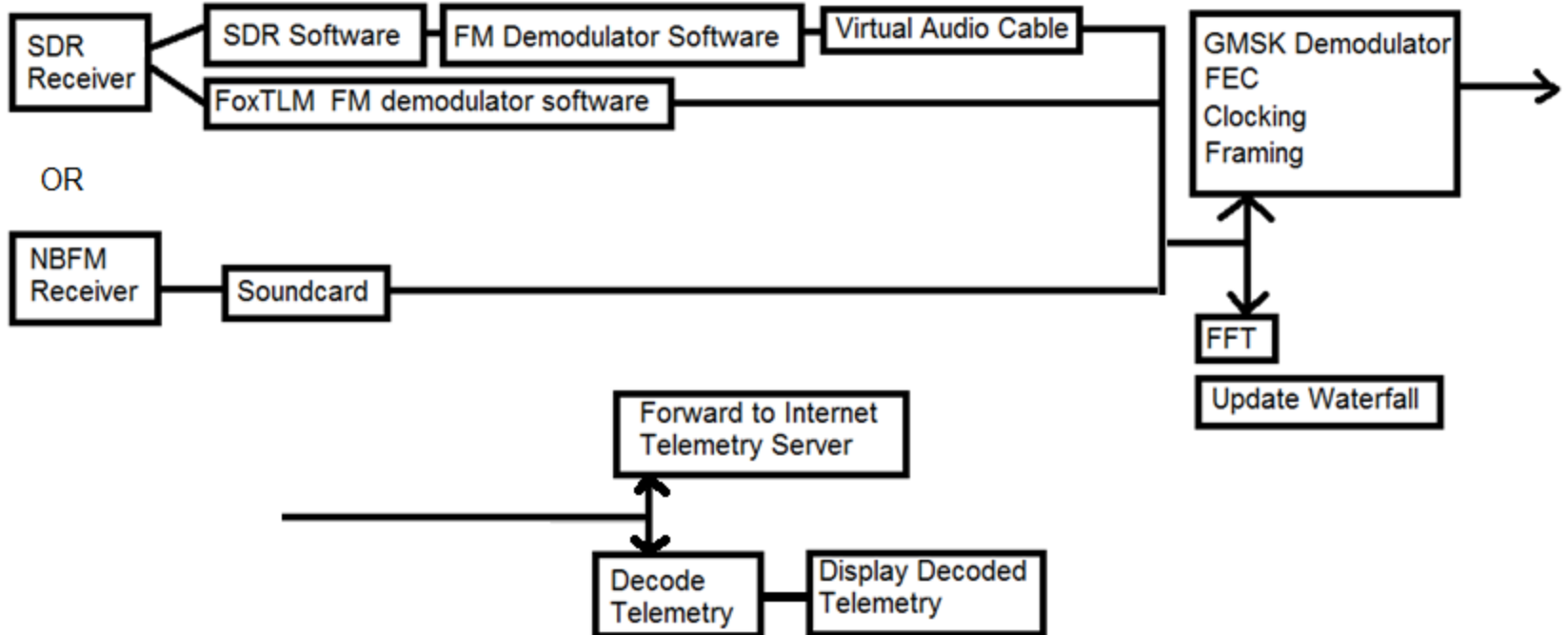
- Easy to install and easy to use software
- Maximize participation from ground stations
- Open Source / GNU Public License (GPL)
- Leverage “lessons learned” from telemetry collection with ARISSat-1 and software development with ARISSatTLM
  - Written in C with Qt framework
  - Support multiple sound cards



# Goals and Objectives

- Support both NBFM and SDR receivers
- Runs on Windows XP and Windows 7 platforms
- Separate coding effort by Gilbert Mackall for Mac
- Qt *should* allow easy porting to Linux systems including devices like the Raspberry Pi
- Software that runs on a 1 GHz class computer

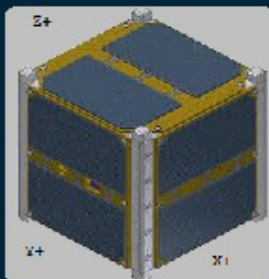
# FoxTLM



# Initial Concept Artwork Ideas

Frames Received 102    Ground Station: KA2UPW    Time to AOS: 00 h 00 m 00 s    Azimuth: 42 degrees    Max Elevation: 66 degrees  
 Frames Forwarded 102    Location: EM13oa    Time to LOS: 00 h 05 m 17 s    Elevation: 45 degrees    Forwarding is ON

Uptime 3 days 14 hrs 23 min  
 Reset Count 4  
 Frame Count 3237  
 Command Count 4  
 Experiment ON



|    | V    | I   | °C |
|----|------|-----|----|
| X+ | 1.27 | 34  | 25 |
| X- | 0.01 | 3   | 24 |
| Y+ | 3.40 | 125 | 27 |
| Y- | 0.03 | 4   | 24 |
| Z+ | 4.27 | 334 | 40 |
| Z- | 0.17 | 10  | 18 |

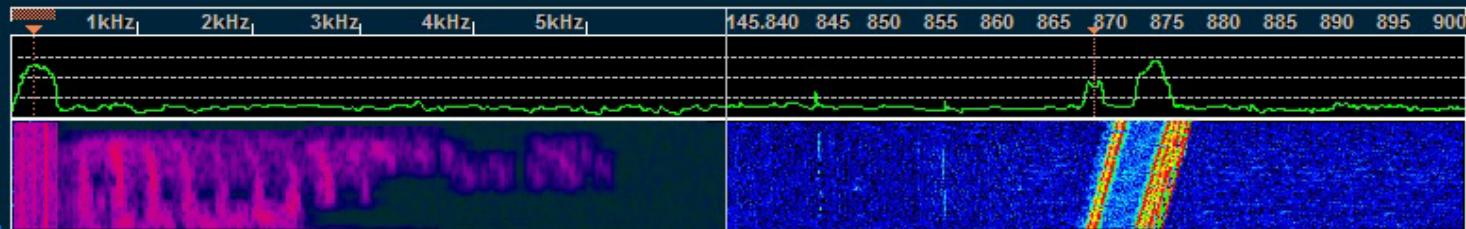
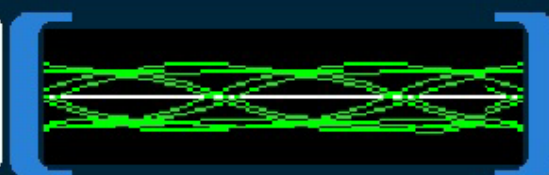
IHU
BCR
Batt
RX
TX
Exp

|            |      |
|------------|------|
| Batt1      | 1.22 |
| Batt2      | 1.21 |
| Batt3      | 1.23 |
| Batt       | 3.66 |
| Batt1 Temp | 25   |
| Batt2 Temp | 25   |
| Batt3 Temp | 26   |



```

00 54 48 69 2E 20 54 68 69-73 20 69 73 20 46 6F 78  THi. This is Fox
10 2D 31 2E 20 5E 23 57 47-53 44 26 52 54 47 23 40  -1. APWGS&RTG#8
20 00 0A 5E 54 47 7E 31 32-7E 40 23 32 33 34 23 24  ..ATG~12~@#234#$
30 36 35 34 35 23 24 5E 34-33 32 35 34 33 41 33 34  6545#$M432543A34
40 33 23 00 0A 00 0A 01 BF-38 01 80 3E 31 01 01 74  3#. ....8...>1..t
50 03 BF 39 01 AA BA 1C 01-80 02 80 3E 24 70 03 72  ..9.....>Sp.f
60 18 A1 0E 70 8E D8 8E CO-2B CO 2B FF B9 FF 7F F2  ...p...+...+....
70 AE AE 75 FB 8D 55 02 B0-12 B4 3D CD 21 07 1F 72  ...U...+...=...f
  
```



# FoxTLM on Windows

FoxTLM Dayton Demo Version 0.3 Registered to AMSAT

File Edit Tools Help

**Fox-1 Uptime 0 days 4 hours 23 min**

Reset Count 4 Commands Received 4  
Frames Sent by Fox-1 247 Experiment Status ON

Ground Station: KAZUPW Frames Received 42 Until next AOS: 00 h 00 m 00 s Azimuth: 42 degrees  
Location: EM13oa Frames Forwarded 42 Until next LOS: 00 h 05 m 17 s Elevation: 45 degrees  
Audio buffers 656 Forwarding is ON

Z+ Vots mA C  
X+ 0.000 0.000 28.8  
X- 2.400 0.666 25.5  
Y+ 0.000 0.000 29.9  
Y- 0.000 0.000 26.6  
Z+ 2.300 0.555 24.4  
Z- 0.000 0.000 27.7

IHU BCR Battery Receiver Experiment Transmitter

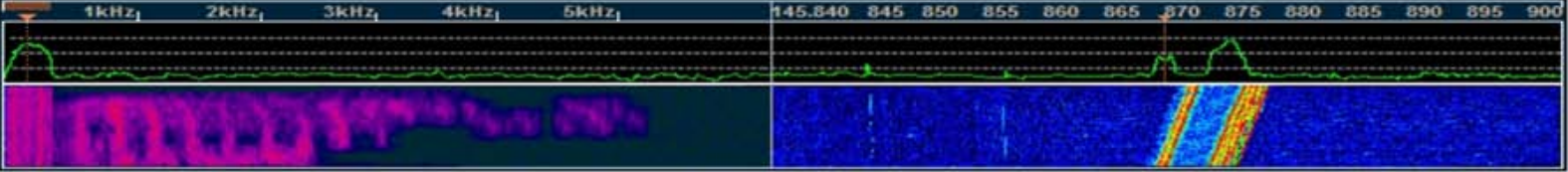
Battery Cell 1 1.20 V  
Battery Cell 2 1.24 V  
Battery Cell 3 1.28 V  
Battery Cell 4 1.32 V  
Battery Cell 5 1.36 V  
Battery Cell 6 1.40 V

Cell 1 Temp 9.10 °C  
Cell 2 Temp 9.20 °C  
Cell 3 Temp 9.30 °C  
Cell 4 Temp 9.40 °C  
Cell 5 Temp 9.50 °C  
Cell 6 Temp 9.60 °C

Battery 1 3.72 V  
Battery 2 4.08 V

00: xx xx xx xx xx xx xx - xx xx xx xx xx xx xx  
10: xx xx xx xx xx xx xx - xx xx xx xx xx xx xx  
20: xx xx xx xx xx xx xx - xx xx xx xx xx xx xx

TH, this is Fox  
-1.kj\*hj&b%\$g3jh  
\$g8s%!~twg%6aadA



# FoxTLM Look and Feel

- Waterfall diagrams for FM receive audio (left side) and SDR RF receive signal at 145Mhz (right side)
- Raw telemetry hex dump and decoded telemetry displays
- Telemetry as Text screen (not shown)
- “Visual” telemetry with pictures - it should look *interesting* to a fifth grader



# FoxTLM

- Forward error correction scheme : still TBD
- High speed experiment telemetry: still TBD
- Another lesson learned: Reuse open source C code from previous projects wherever possible (waterfall/FFT code from AO40Rcv/ARISSatTLM or FFTW, native Qt audio routines or reuse ARISSatTLM C source code)

# Telemetry Web pages

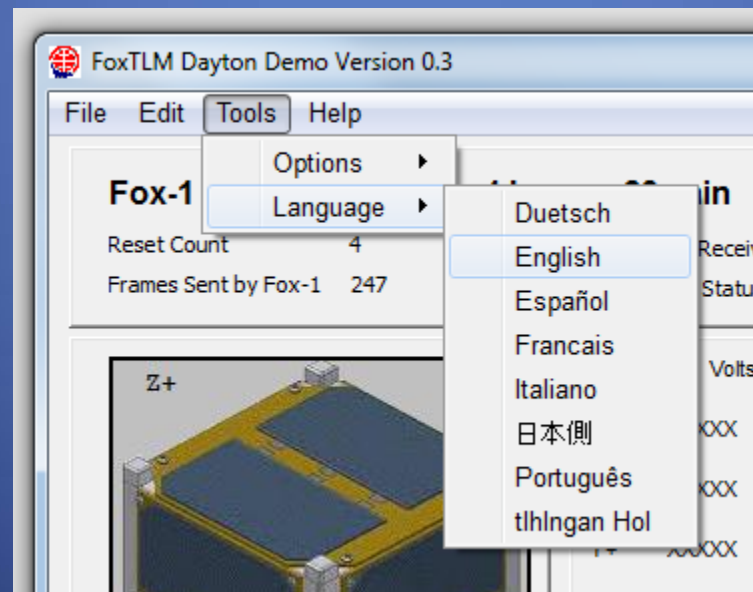
- FoxTLM.org (or AMSAT) web pages similar to the ARISSatTLM telemetry web pages
  - desktop (large screen)
  - mobile devices (small screen)
- Webpages updated about once a minute when telemetry is being received and submitted by ground stations
- Leaderboard telemetry statistics
  - Encourage competition → more telemetry collected
  - All time “high score” telemetry submitters
  - Last 30 days statistics
  - Top schools submitting telemetry
- “Raw” and “cooked” telemetry data to be archived on [amsat.org](http://amsat.org) (includes telemetry .CSV files)

# Ideas and Stretch goals

- Measure the downlink RF frequency, time of closest approach and Doppler shift of the downlink using an SDR receiver
- Report the UTC time, ground station location and Doppler measurements to the Internet telemetry server for later orbital analysis → do-it-yourself orbital elements
- Possibly a college level educational project (grade 13-16)

# Ideas and Stretch goals II

- Multiple language translations using Qt tr() translate functions
- Assumes the existence of volunteer translators to provide the translations)

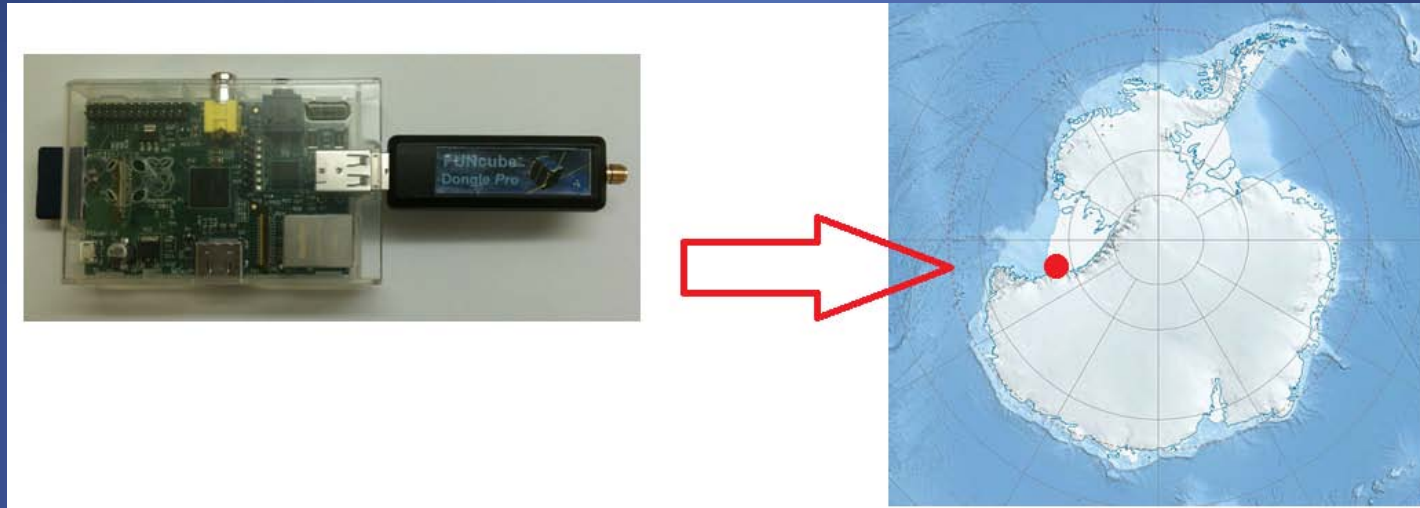


# Ideas and Stretch goals III



An automated unattended telemetry ground station using a Raspberry Pi and a FUNcube dongle with QtonPi (a Linux distribution optimized for running Qt applications)

# But wait...there's more



More ground stations + more coverage = more telemetry

Deploy this to a remote location with an Internet connection in Alaska or Hawaii or McMurdo Station (which has over a dozen passes per day! Updated telemetry every ninety minutes.)

? ? ? Questions ? ? ?

What questions do you have?

Douglas

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