FUNcube-1 (AO-73)
2 Meter Satellite Telemetry

David Haworth, WA90NY
www.stargazing.net/david
CubeSat: Small Standard Size Satellites

- **Standard sizes**
  - 1U: 10 cm cube, mass <1.33 kilograms
  - 2U: 2x1U
  - 3U: 3x1U

- **Common deployment system**
  - Poly-PicoSatellite Orbital Deployer (P-POD)

Image Credit: CubeSat Design Specification Rev. 13
FUNCube-1 Satellite

AMSAT-UK
http://amsat-uk.org/

FUNCube
http://funcube.org.uk/

FUNCube Warehouse
http://warehouse.funcube.org.uk/

AMSAT-NL
http://amsat-nl.org/
1U CubeSat: FUNcube-1, AO-73

Image Credit: Wouter Weggelaar PA3WEG
1U CubSat: FUNcube-1, AO-73

Image Credit: Wouter Weggelaar PA3WEG
1U CubSat: FUNcube-1, AO-73
**FUNcube-1, AO-73**

Launch Date: November 2013, Mission Goal 1 Year

<table>
<thead>
<tr>
<th><strong>Mission type</strong></th>
<th>Amateur Radio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operator</strong></td>
<td>AMSAT-NL</td>
</tr>
<tr>
<td><strong>COSPAR ID</strong></td>
<td>2013-066AE</td>
</tr>
<tr>
<td><strong>SATCAT No</strong></td>
<td>39444</td>
</tr>
<tr>
<td><strong>Website</strong></td>
<td>funcube.org.uk</td>
</tr>
</tbody>
</table>

**Spacecraft properties**

<table>
<thead>
<tr>
<th><strong>Bus</strong></th>
<th>1U CubeSat[^1]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Manufacturer</strong></td>
<td>ISIS-BV, AMSAT-NL, AMSAT-UK</td>
</tr>
<tr>
<td><strong>Launch mass</strong></td>
<td>0.98 kilograms (2.2 lb)</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>2.2 watts</td>
</tr>
</tbody>
</table>

**Start of mission**

<table>
<thead>
<tr>
<th><strong>Launch date</strong></th>
<th>21 November 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rocket</strong></td>
<td>dnepr</td>
</tr>
<tr>
<td><strong>Launch site</strong></td>
<td>Yasny Launch Base</td>
</tr>
<tr>
<td><strong>Contractor</strong></td>
<td>ISL</td>
</tr>
</tbody>
</table>

**Orbital parameters**

<table>
<thead>
<tr>
<th><strong>Reference system</strong></th>
<th>Geocentric</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regime</strong></td>
<td>Low Earth</td>
</tr>
</tbody>
</table>

[^1]: Source: [funcube_oct2013fin.ppt](#), [Table Credit: http://en.wikipedia.org/wiki/FUNcube-1](#)
FUNcube-1 Telemetry (TLM)

2 Modes: High Power M-F Mornings, Low Power Other Times

- **In sunlight full power 300 mW TLM**
  - TLM down link freq 145.935 MHz +/- Doppler
  - Monday – Friday mornings Europe time
  - Transponder off

- **In eclipse low power 30 mW TLM plus**
  - Transponder evenings & weekends
  - Surface to satellite to surface communications
  - Uplink 435.150 - 435.130 MHz CW & LSB (Inverting)
  - Downlink 145.950 - 145.970 MHz CW & USB

FUNcube-1 Status:  http://warehouse.funcube.org.uk/
FUNcube-1 Telemetry (TLM)

Low power TLM beacon with transponder

Airspy SDR Receiver SDR# v1.0.0.1332
Satellite FUNcube-1 with Airspy

https://youtu.be/A52CzLLtbTY
What is Needed to Receive TLM

- 2 m antenna
- 2 m USB receiver
- Windows PC
  - With audio line input
  - Internet connection
- FUNcube-1 Dashboard software
- Satellite position information
WA9ONY Receiving Equipment

SDR with a 4 element Yagi antenna

Antenna: 4 elements Yagi Arrow II Portable Antenna Model 146-4 II

http://arrowantennas.com/arrowii/146-4ii.html
WA9ONY Receiving Equipment

SDR with a 4 element Yagi antenna

Receiver: Airspy software defined radio (SDR)

- SDR# V1.0.0.1337 software for Airspy
- http://www.sdrsharp.com/

Optional

- Preamp: Mini-Circuits ZFL-500LN+ Amplifier 24 dB.

Filters: after the preamp

- Mini-Circuits VHF-145+ 140 to 1150 MHz high pass filter.
- Mini-Circuits BLP-200 190 MHz low pass filter.
WA9ONY Receiving Software

i7 core laptop with Windows 8.1

Behringer XENYX 302 USB audio mixer to USB
 Audio line input
  http://www.behringer.com/EN/Products/302USB.aspx

FUNcube Telemetry Dashboard v848
  http://funcube.org.uk/working-documents/funcube-telemetry-dashboard/
WA9ONY Software

i7 core laptop with Windows 8.1

Ridiculously Simple Network Time Protocol (NTP) Client

by Wolfgang "Wolf" DL4YHF for time keeping

http://www.qsl.net/dl4yhf/rsNTP/rsNTP.htm

IrfanView 4.38 for taking screen captures

http://www.irfanview.com/
SDR# & Dashboard

MOVE-1 CW Beacon
FUNcube-1 Signal Fading

MOVE-1 CW Beacon
FUNcube-1 Dashboard, Real Time Data

- Data Collection
  - Sun Sensors
    - Panel X
    - Panel Y
    - Panel Z
  - Total Panel Current
  - Battery Voltage
- Decoding
  - BPSK 47
  - Frequency 6182
- Radio Board (RF)
  - CORDX Doppler 158.5 kHz
  - CORDX RXS III 180 dBm
  - Temp -0.01°C
  - 3 dB Current 37 mA
  - 5 dB TX Current 54 mA
- Power (EPS)
  - Bus Current 141 mA
  - Panel Current 221 mA
  - Boost Cond1 Temp -1°C
  - Boost Cond2 Temp +1°C
- Battery Voltage 8.333 mV
- Temperature
  - Antenna A: 39°C
- Navigation
  - Real Time Data
  - High Resolution Data
  - Whole Orbit Data
  - Filter Messages
  - Amateur Radio Info
  - Satellite Position
  - Upload Banner
  - About

Real Time Data

This page shows the latest value of all the housekeeping parameters in the spacecraft. The data has been collected by one or more of the ground stations who are submitting this data from all around the world.

To download a .csv file which contains Realtime data, please click [here]. This data is generated every hour, on the hour and contains the preceding 250 minutes of information.

The data/time in the .csv file is "Satellite Time." It is based on the number of sequences / frames it has transmitted since spacecraft initialization after separation (2013-11-21 07:28:16).

This time will drift as it is based on the MCU clock which is not temperature controlled. In the future we may be able to give real-time if we can model the drift.

Data Providers
- WAKONY

Warehouse Info
- Seq #: 315558
- Packets: 1840772 (471.2MB)

Electrical Power Subsystem
- Satellite Latitude: 45.9 N
- Longitude: 130.0 W

Satellite Status
- Mode switching: Manual
- Transponder state: On
FUNcube-1, AO-73 Position

http://warehouse.funcube.org.uk/satmap.html?satelliteId=2

Current Satellite Position
FUNcube-1, AO-73 Position


<table>
<thead>
<tr>
<th>Date (UTC)</th>
<th>AOS (UTC)</th>
<th>Duration</th>
<th>AOS Azimuth</th>
<th>Maximum Elevation</th>
<th>Max El Azimuth</th>
<th>LOS Azimuth</th>
<th>LOS (UTC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>08 Feb 15</td>
<td>03:58:46</td>
<td>00:11:07</td>
<td>116</td>
<td>14</td>
<td>55</td>
<td>5</td>
<td>04:09:53</td>
</tr>
<tr>
<td>08 Feb 15</td>
<td>05:33:17</td>
<td>00:13:38</td>
<td>189</td>
<td>75</td>
<td>240</td>
<td>348</td>
<td>05:46:53</td>
</tr>
<tr>
<td>08 Feb 15</td>
<td>07:12:19</td>
<td>00:09:43</td>
<td>229</td>
<td>8</td>
<td>270</td>
<td>321</td>
<td>07:22:02</td>
</tr>
<tr>
<td>08 Feb 15</td>
<td>17:20:18</td>
<td>00:11:16</td>
<td>28</td>
<td>17</td>
<td>90</td>
<td>153</td>
<td>17:31:34</td>
</tr>
<tr>
<td>08 Feb 15</td>
<td>19:56:16</td>
<td>00:12:39</td>
<td>7</td>
<td>46</td>
<td>210</td>
<td>16:08:55</td>
<td></td>
</tr>
<tr>
<td>08 Feb 15</td>
<td>20:34:01</td>
<td>00:07:44</td>
<td>345</td>
<td>5</td>
<td>319</td>
<td>270</td>
<td>20:41:45</td>
</tr>
<tr>
<td>09 Feb 15</td>
<td>04:10:34</td>
<td>00:12:06</td>
<td>128</td>
<td>21</td>
<td>68</td>
<td>0</td>
<td>04:30:40</td>
</tr>
<tr>
<td>09 Feb 15</td>
<td>05:53:57</td>
<td>00:13:32</td>
<td>161</td>
<td>48</td>
<td>271</td>
<td>342</td>
<td>06:07:29</td>
</tr>
<tr>
<td>09 Feb 15</td>
<td>07:34:31</td>
<td>00:07:04</td>
<td>247</td>
<td>3</td>
<td>273</td>
<td>311</td>
<td>07:41:35</td>
</tr>
<tr>
<td>09 Feb 15</td>
<td>17:40:34</td>
<td>00:12:11</td>
<td>23</td>
<td>27</td>
<td>82</td>
<td>166</td>
<td>17:52:45</td>
</tr>
</tbody>
</table>

Your results are shown above
Use the form below to request more pass predictions

Show Predictions for: AO-73

Calculate Latitude and Longitude from Gridsquare:

Calculate Position

Or

Enter Decimal Latitude:* 45.6875  North

Enter Decimal Longitude:* 122.375  West

Elevation (Metres): 300

Predict

☐ Save my location for later use
Current Position of AO-73

Sun, 08 Feb 2015 01:46:43 GMT (17:46:43 local time)
Current Location: 70E 81S

Select a Different Satellite: AO-73

Note: Position is approximate and depends on your computer’s performance.

Gpredict on MacBook Pro

Ubuntu Linux 14.04 on Parallels Desktop 10
Gpredict on MacBook Pro

Ubuntu 14.04 Software Center Easy Install

Gpredict is a real-time satellite tracking program for GNOME, based on the tracking engine of John Magliacane's excellent satellite tracker Predict.

Gpredict includes the following features:

- Tracking an infinite number of satellites limited only by the physical memory and processing power of the computer.
- Display the tracking data in lists, maps, polar plots or any combination of these.
- You can have many modules open at the same time, either in a notebook or in their own windows. The module can also run in full-screen mode.
- You can use many ground stations. Ground station coordinates can be entered manually or you can get some approximate values from a list with more than 2000 predefined locations worldwide.
- Predict upcoming passes for satellites, including passes where a satellite may be visible and communication windows open.
- Very detailed information about both the real-time data and the predicted passes.
- Gpredict can run in real-time, simulated real-time (fast forward and backward), and manual time control.
- Doppler tuning of radios via Hamlib cmd.
- Antenna rotator control via Hamlib cmd.

Version gpredict 1.3-2ubuntu2

http://gpredict.oz9aec.net/
Gpredict Keplerian Elements

Elements define the satellite orbit

http://gpredict.oz9aec.net/
Gpredict Custom Layout

Main window has 5 panels

http://gpredict.oz9aec.net/
Can the satellite & you see each other

http://gpredict.oz9aec.net/
Gpredict Satellite Location in Sky
Altitude-Azimuth Position for pointing the antenna

Azimuth : 287.60°
Elevation : 78.13°
Direction : Approaching
Slant Range : 630 km
Range Rate : -0.123 km/sec
Next Event : LOS: 2015/02/07 18:48:34
Next AOS : 2015/02/07 20:12:56
Next LOS : 2015/02/07 18:48:34
SSP Loc. : CN85BX
Footprint : 5402 km
Altitude : 618 km
Velocity : 7.565 km/sec
Doppler@100M : 41 Hz
Sig. Loss : 128.39 dB
Sig. Delay : 2.10 msec
Mean Anom. : 211.90°
Orbit Phase : 297.99°
Orbit Num. : 6426
Visibility : Daylight

http://gpredict.oz9aec.net/
Gpredict Satellite Prediction

Acquisition of signal (AOS) & Lost of signal (LOS)

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Az</th>
<th>El</th>
<th>Δ AOS/LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>UO-11</td>
<td>11.12°</td>
<td>-14.64°</td>
<td>05:04</td>
</tr>
<tr>
<td>FUNCUBE-1 (AO-73)</td>
<td>287.60°</td>
<td>78.13°</td>
<td>06:21</td>
</tr>
<tr>
<td>AO-7</td>
<td>106.17°</td>
<td>-45.97°</td>
<td>25:52</td>
</tr>
<tr>
<td>NO-44</td>
<td>301.64°</td>
<td>-81.18°</td>
<td>39:28</td>
</tr>
<tr>
<td>DELFI-C3 (DO-64)</td>
<td>177.25°</td>
<td>-82.54°</td>
<td>45:35</td>
</tr>
<tr>
<td>UKUBE-1</td>
<td>189.09°</td>
<td>-81.67°</td>
<td>46:04</td>
</tr>
<tr>
<td>ISS</td>
<td>224.77°</td>
<td>-50.06°</td>
<td>06:51:16</td>
</tr>
</tbody>
</table>

http://gpredict.oz9aec.net/
## Gpredict

List of satellites on 2 meters band

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Az</th>
<th>El</th>
<th>Dir</th>
<th>Range</th>
<th>Next AOS</th>
<th>Next LOS</th>
<th>Dop</th>
<th>Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>AO-7</td>
<td>106.17°</td>
<td>-45.97°</td>
<td>↑</td>
<td>11043</td>
<td>2015/02/07 19:08:05</td>
<td>2015/02/07 19:18:56</td>
<td>1194</td>
<td>153.26</td>
</tr>
<tr>
<td>DELFI-C3 (DO-64)</td>
<td>177.25°</td>
<td>-82.54°</td>
<td>↓</td>
<td>13227</td>
<td>2015/02/07 19:27:48</td>
<td>2015/02/07 19:38:04</td>
<td>-287</td>
<td>154.83</td>
</tr>
<tr>
<td>FUNCUBE-1 (AO-73)</td>
<td>287.60°</td>
<td>78.13°</td>
<td>↑</td>
<td>630</td>
<td>2015/02/07 20:12:56</td>
<td>2015/02/07 18:48:34</td>
<td>41</td>
<td>128.39</td>
</tr>
<tr>
<td>ISS</td>
<td>224.77°</td>
<td>-50.06°</td>
<td>↑</td>
<td>10282</td>
<td>2015/02/08 01:33:29</td>
<td>2015/02/08 01:42:56</td>
<td>69</td>
<td>152.64</td>
</tr>
<tr>
<td>NO-44</td>
<td>301.64°</td>
<td>-81.18°</td>
<td>↑</td>
<td>13400</td>
<td>2015/02/07 19:21:42</td>
<td>2015/02/07 19:37:21</td>
<td>301</td>
<td>154.94</td>
</tr>
<tr>
<td>UKUBE-1</td>
<td>189.09°</td>
<td>-81.67°</td>
<td>↓</td>
<td>13240</td>
<td>2015/02/07 19:28:17</td>
<td>2015/02/07 19:40:15</td>
<td>-339</td>
<td>154.84</td>
</tr>
<tr>
<td>UO-11</td>
<td>11.12°</td>
<td>-14.64°</td>
<td>↑</td>
<td>4937</td>
<td>2015/02/07 18:47:17</td>
<td>2015/02/07 18:59:33</td>
<td>2215</td>
<td>146.27</td>
</tr>
</tbody>
</table>

[http://gpredict.oz9aec.net/](http://gpredict.oz9aec.net/)
# 2 Meters 144-148 MHz Band Plan

<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>144.00-144.05</td>
<td>EME (CW)</td>
</tr>
<tr>
<td>144.05-144.10</td>
<td>General CW and weak signals</td>
</tr>
<tr>
<td>144.10-144.20</td>
<td>EME and weak-signal SSB</td>
</tr>
<tr>
<td>144.200</td>
<td>National calling frequency</td>
</tr>
<tr>
<td>144.200-144.275</td>
<td>General SSB operation</td>
</tr>
<tr>
<td>144.275-144.300</td>
<td>Propagation beacons</td>
</tr>
<tr>
<td>144.30-144.50</td>
<td>New OSCAR subband</td>
</tr>
<tr>
<td>144.50-144.60</td>
<td>Linear translator inputs</td>
</tr>
<tr>
<td>144.60-144.90</td>
<td>FM repeater inputs</td>
</tr>
<tr>
<td>144.90-145.10</td>
<td>Weak signal and FM simplex (145.01,03,05,07,09 are widely used for packet)</td>
</tr>
<tr>
<td>145.10-145.20</td>
<td>Linear translator outputs</td>
</tr>
<tr>
<td>145.20-145.50</td>
<td>FM repeater outputs</td>
</tr>
<tr>
<td>145.50-145.80</td>
<td>Miscellaneous and experimental modes</td>
</tr>
<tr>
<td>145.80-146.00</td>
<td>OSCAR subband</td>
</tr>
<tr>
<td>146.01-146.37</td>
<td>Repeater inputs</td>
</tr>
<tr>
<td>146.40-146.58</td>
<td>Simplex</td>
</tr>
<tr>
<td>146.52</td>
<td>National Simplex Calling Frequency</td>
</tr>
<tr>
<td>146.61-146.97</td>
<td>Repeater outputs</td>
</tr>
<tr>
<td>147.00-147.39</td>
<td>Repeater outputs</td>
</tr>
<tr>
<td>147.42-147.57</td>
<td>Simplex</td>
</tr>
<tr>
<td>147.60-147.99</td>
<td>Repeater inputs</td>
</tr>
</tbody>
</table>

Image Credit: [http://www.arrl.org/band-plan](http://www.arrl.org/band-plan)
# 2 Meters 145.8-146.0 MHz Satellites

## January 2015

<table>
<thead>
<tr>
<th>Frequency MHz</th>
<th>Satellite</th>
<th>Notes</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>+/– Doppler</td>
<td>145.800–146.000 MHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>145.825</td>
<td>Navy-OSCAR 44, NO-44, PCsat</td>
<td>FM FSK, AX.25, 1k2 and 9k6 in Sun only</td>
<td></td>
</tr>
<tr>
<td>145.825</td>
<td>ISS</td>
<td>FM FSK, AX.25 packet</td>
<td></td>
</tr>
<tr>
<td>145.825</td>
<td>UoSAT OSCAR, UO-11</td>
<td>FM 1k2 AFSK ASCII</td>
<td></td>
</tr>
<tr>
<td>145.870</td>
<td>DELFI-OSCAR 64, DO-64, DELFI-C3</td>
<td>CW and 1k2 BPSK AX.25</td>
<td></td>
</tr>
<tr>
<td>145.915</td>
<td>FUNcube-2, UKube-1</td>
<td>30mW or 300 mW Telemetry Beacon 1200 bps BPSK, same as FUNcube-1 AO-7</td>
<td></td>
</tr>
<tr>
<td>145.935</td>
<td>FUNcube-1, AO-7</td>
<td>30mW or 300 mW Telemetry Beacon 1200 bps BPSK</td>
<td>20150104 1809UT</td>
</tr>
<tr>
<td>145.925 - 145.975</td>
<td>AMSAT OSCAR 7, AO-7</td>
<td>Mode U/V (B) Linear Transponder (Inverting) alternates with Mode A USB and CW when in the Sun</td>
<td></td>
</tr>
<tr>
<td>145.950 - 145.970</td>
<td>FUNcube-1, AO-7</td>
<td>Transponder Downlink USB and CW</td>
<td>20150104 1809UT</td>
</tr>
<tr>
<td>145.9775</td>
<td>AMSAT OSCAR 7, AO-7</td>
<td>CW Beacon when in the Sun</td>
<td></td>
</tr>
</tbody>
</table>

[http://www.stargazing.net/david/satellites/2meters.html](http://www.stargazing.net/david/satellites/2meters.html)
Gpredict Doppler Shift

+ Frequency Coming, - Frequency Going

http://gpredict.oz9aec.net/
Frequency Doppler Shift

UKube-1 TLM, FUNcube-1 TLM

Airspy SDR Receiver
SDR# v1.0.0.1332
FUNcube-1 & UKube-1 signals with Airspy

Saturday 2015-2-7 Passes
Camas WA, USA

Upcoming passes for FUNCUBE-1 (AO-73)

<table>
<thead>
<tr>
<th>AOS</th>
<th>LOS</th>
<th>Duration</th>
<th>Max El</th>
<th>AOS Az</th>
<th>LOS Az</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015/02/07 17:00:11</td>
<td>2015/02/07 17:10:14</td>
<td>00:10:03</td>
<td>10.46°</td>
<td>34.99°</td>
<td>138.87°</td>
</tr>
<tr>
<td>2015/02/07 18:35:39</td>
<td>2015/02/07 18:48:34</td>
<td>00:12:54</td>
<td>77.20°</td>
<td>11.16°</td>
<td>198.18°</td>
</tr>
<tr>
<td>2015/02/07 20:12:56</td>
<td>2015/02/07 20:22:27</td>
<td>00:09:30</td>
<td>9.41°</td>
<td>351.10°</td>
<td>255.42°</td>
</tr>
<tr>
<td>2015/02/08 03:58:45</td>
<td>2015/02/08 04:09:52</td>
<td>00:11:06</td>
<td>14.23°</td>
<td>115.73°</td>
<td>4.71°</td>
</tr>
<tr>
<td>2015/02/08 05:33:16</td>
<td>2015/02/08 05:46:52</td>
<td>00:13:36</td>
<td>76.21°</td>
<td>169.41°</td>
<td>346.14°</td>
</tr>
<tr>
<td>2015/02/08 07:12:17</td>
<td>2015/02/08 07:22:01</td>
<td>00:09:43</td>
<td>8.19°</td>
<td>228.45°</td>
<td>321.22°</td>
</tr>
</tbody>
</table>

http://gpredict.oz9aec.net/
Saturday Morning 2015-2-7 Passes

Camas WA, USA

2 Frames

46 Frames

3 Frames

http://gpredict.oz9aec.net/
Saturday Evening 2015-2-7 Passes

Camas WA, USA

0 Frames
74 Frames
3 Frames

http://gpredict.oz9aec.net/
Low Pass in the East at 30 mW

2 frames with 2 receivers 2 antennas

http://gpredict.oz9aec.net/
Two 4 Element Yagi Antennas

East at 30° alt & west at 30° alt

Arrow II Portable Antenna Model 146-4 II
High Pass at 30 mW

46 frames with 2 receivers 2 antennas

http://gpredict.oz9aec.net/
Upload Ranking of 859 Submitters

We should like to thank all the groups and individuals who have uploaded data to the FUncube data warehouse.

The following list gives the site names of those who have uploaded the most data frames:

Key: **Within 1 week, within 2 weeks, greater than 2 weeks**

<table>
<thead>
<tr>
<th>Site Id</th>
<th>Count</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>g0mjq</td>
<td>333189</td>
<td>1</td>
</tr>
<tr>
<td>OM3BC</td>
<td>276570</td>
<td>2</td>
</tr>
<tr>
<td>W0JW</td>
<td>222598</td>
<td>3</td>
</tr>
<tr>
<td>HB9MFL</td>
<td>204458</td>
<td>4</td>
</tr>
<tr>
<td>VK5HI</td>
<td>194222</td>
<td>5</td>
</tr>
<tr>
<td>g4ovr</td>
<td>29014</td>
<td>104</td>
</tr>
<tr>
<td>GW1FKY</td>
<td>28876</td>
<td>105</td>
</tr>
<tr>
<td>WA9ONY</td>
<td>27969</td>
<td>106</td>
</tr>
<tr>
<td>JO1PTD</td>
<td>27967</td>
<td>107</td>
</tr>
<tr>
<td>VK2EBV</td>
<td>27511</td>
<td>108</td>
</tr>
</tbody>
</table>

Started Jan. 2015

http://warehouse.funcube.org.uk/ranking.html
Real Time Data

4 data providers for Seq. #319,173 Packet #1,861,411

http://warehouse.funcube.org.uk/realtime.html?satelliteId=2
NH6Y 2,577.1 mi Distance from WA9ONY

THOMAS K WORTHINGTON
1035 NAALAE RD
KULA, HI 96790
USA

Email: Use mouse to view..

Ham Member Lookups: 19997

Lookups 19997 (28890)
QRZ Record# 1786998
QRZ Admin NH6Y
Date Joined 2009-01-28 22:59:17
Last Update 2014-12-10 21:19:41
Class E
Effective 2011-08-12
Latitude 20.756000 (20° 45' 21" N)
Longitude -156.342000 (156° 20' 31" W)
Grid Square BL10ts
Geo Source User supplied
US State Hawaii
US County Maui
Bearing 239.6° WSW (from WA9ONY)
Distance 2577.1 mi (4147.4 km)

http://qrz.com/
FUNcube-1 Footprint

Both WA9ONY & NH6Y see FUNcube-1 TLM at the same time

http://gpredict.oz9aec.net/
Real Time Data

WA9ONY only data provider for Seq. No.: 319,454

http://warehouse.funcube.org.uk/realt ime.html?satelliteId=2
FUNcube-1 Satellite Telemetry Upload

https://youtu.be/jUP6vdjaS9o

http://warehouse.funcube.org.uk/realtime.html?satelliteId=2
58 Telemetry Channels

FUNcube-1 Dashboard decodes the TLM BPSK with FEC

http://funcube.org.uk/working-documents/funcube-telemetry-dashboard/
58 Telemetry Channels

- Real-time measurements every five seconds

- High resolution data
  - Satellite stores last 60 real-time measurements

- Whole orbit data
  - Satellite stores 104 measurements
  - One measurement per minute
Telemetry Transmission Organization

2 minutes for sequence, 5 seconds per frame

- Sequence is composed of 24 frames
- Frame is composed of 256 bits of data after decode
- Frame always contains real-time data

Sequence structure
- 12 whole orbit frames WO1 to WO12
- 1 high resolution frame HR1
- 3 Fitter messages FM1 to FM3
- 1 high resolution frame HR2
- 3 Fitter messages FM4 to FM6
- 1 high resolution frame HR3
- 3 Fitter messages FM7 to FM9
14 Whole Orbit Data Sets
104 Measurements During 1 Orbit, 1 Minute Intervals

Satellite Saves 1 Orbit of Data Onboard
Black Chassis Temp Whole Orbit Graph
Measurements During 1 Orbit, 1 Minute Intervals

FUNcube-1 Data Received by WA9ONY 2015-2-5
http://funcube.org.uk/working-documents/funcube-telemetry-dashboard/
Black Chassis Temp

Whole Orbit Graph

Satellite in Sun

In eclipse

In Sun

Satellite Spinning in the Sun

http://funcube.org.uk/working-documents/funcube-telemetry-dashboard/
Sun Energy Received Equals Energy Radiated into Space
Black Chassis Temp
Whole Orbit Graph

In Sun
In eclipse
In Sun

Increase in atmosphere decreases Sun energy received
Silver Chassis Temp
Smaller Δ Temp
Slower Rate of Energy Radiated into Space

Black Chassis Temp
Larger Δ Temp
Faster Rate of Energy Radiated into Space
Solar Panel Voltage Y

Whole Orbit Graph

Satellite in Sun | In eclipse | In Sun

Image Credit: Wouter Weggelaar PA3WEG
FUNcube-1 Data Received by WA9ONY 2015-2-5
http://funcube.org.uk/working-documents/funcube-telemetry-dashboard/
Fitter Messages (FM)
9 FM 200 characters each transmitted by the satellite

<table>
<thead>
<tr>
<th>Receive Time</th>
<th>Sequence</th>
<th>Packet</th>
<th>Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>2/5/2015 6:02:01 PM</td>
<td>319123</td>
<td>FM9</td>
<td>2d * V E &amp; &amp; e395m 94e73e 94e73e 94e73e 94e73e 94e73e072c541c 94e73e 94e73e 94e73e</td>
</tr>
<tr>
<td>2/5/2015 6:01:49 PM</td>
<td>319123</td>
<td>FM7</td>
<td>For details of the education resources check <a href="http://www.funcube.org.uk/education-outreach">www.funcube.org.uk/education-outreach</a>.</td>
</tr>
<tr>
<td>2/5/2015 6:01:38 PM</td>
<td>319123</td>
<td>FM6</td>
<td>Hello world, this is 5JW from Central Walker primary in Newcastle upon Tyne, UK.</td>
</tr>
<tr>
<td>2/5/2015 6:01:32 PM</td>
<td>319123</td>
<td>FM5</td>
<td>The 73 on 73 Award is organised by Paul N8HM see <a href="http://amwat-uk.org/2014/08/18/73-on-73-award-announcement">http://amwat-uk.org/2014/08/18/73-on-73-award-announcement</a></td>
</tr>
<tr>
<td>2/5/2015 6:01:26 PM</td>
<td>319123</td>
<td>FM4</td>
<td>If you can read this you are receiving FUNcube fine. Please register with the FUNcube data warehouse at <a href="http://api.funcube.org.uk/">http://api.funcube.org.uk/</a></td>
</tr>
<tr>
<td>2/5/2015 6:01:09 PM</td>
<td>319123</td>
<td>FM2</td>
<td>Call all schools - if you would like a Fitter message uploaded please email <a href="mailto:operations@funcube.org.uk">operations@funcube.org.uk</a></td>
</tr>
<tr>
<td>2/5/2015 6:01:03 PM</td>
<td>319123</td>
<td>FM1</td>
<td>The main FUNcube tech team is: Dave G4DPZ, David G0MRF, Duncan M6UCK, Gerard Aalbers, Graham G3VZV, Jason G7OCD, Jim G3WGM, Howard G6LV8, Phil M6IPX, Wouter PA3WEG &amp; Wouter Jan PE4WJ</td>
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<td>319122</td>
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<td>2d ^ V E &amp; &amp; e395m 94e73e 94e73e 94e73e 94e73e 94e73e072c541c 94e73e 94e73e 94e73e</td>
</tr>
<tr>
<td>2/5/2015 5:59:35 PM</td>
<td>319122</td>
<td>FM8</td>
<td>More information about this spacecraft, orbital details, etc an the telemetry decoder and dashboard can be downloaded from <a href="http://www.funcube.org.uk">http://www.funcube.org.uk</a></td>
</tr>
<tr>
<td>2/5/2015 5:59:49 PM</td>
<td>319122</td>
<td>FM7</td>
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</tr>
</tbody>
</table>

Send school messages to operations@funcube.org.uk

FUNcube-1 Data Received by WA9ONY 2015-2-5
http://funcube.org.uk/working-documents/funcube-telemetry-dashboard/
www.stargazing.net/david/satellites/2meters.html

Summary

Listening to the International Space Station (ISS) and satellites in orbit with a focus on radio signals in the amateur radio 2 meter band comprising frequencies from 144.000 MHz to 148.000 MHz.

The satellite radio signals are classified into two groups: voice and data transmissions.

Presentation

FUNcube-1 (AO-73) 2 Meter Satellite Telemetry presentation at SEA-PAC June 6, 2015

2 Meters Band Satellite Plan