

Mode S Beast vs Airspy

Blort

November 29, 2015

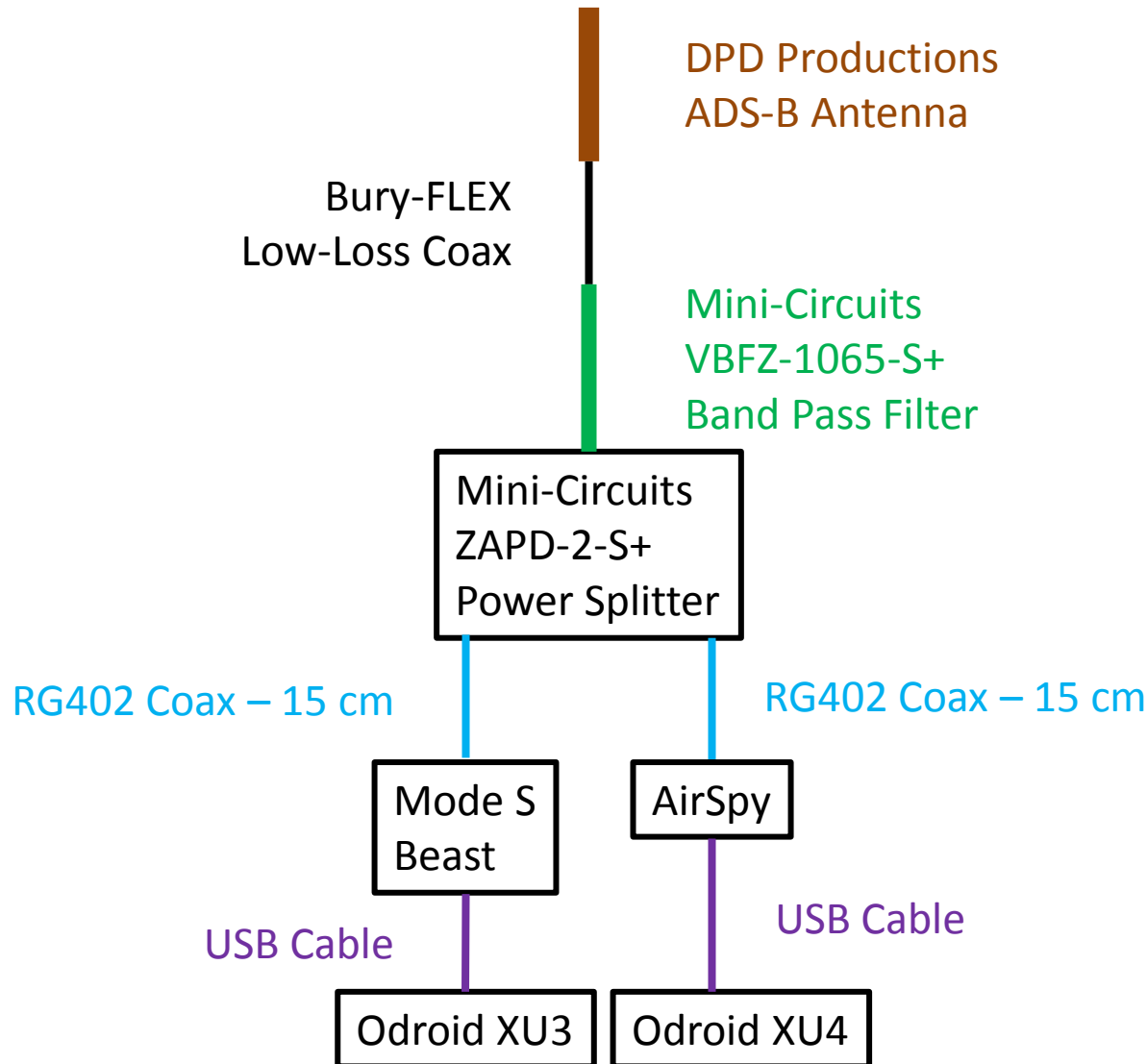
Reasons for Beast vs Airspy Test

- This past year has introduced the Airspy with ADS-B software that runs on a low-power Linux Computer
- Because the Airspy is cheaper than the Mode S Beast (hereafter referred to as “Beast”), I wanted to see if the Airspy was a viable alternative to the Beast
- So I put together a test of the two devices and researched the costs of Beast and Airspy ADS-B systems

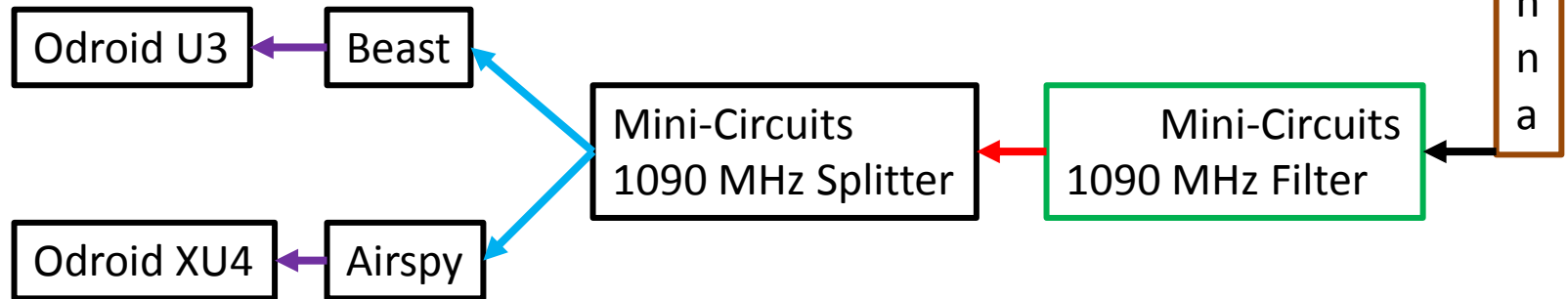
Beast vs Airspy Test

- The test simultaneously runs both the Beast and the Airspy from the same RF source using Odroid computers
- Unfortunately, I don't have two Odroid XU4s - so I used an Odroid XU4 for the Airspy (as it has the most powerful processors) and an Odroid U3 for the Beast
- The test did not enable Mode A/C on either device as this data is really only useful for Plane Plotter applications and it creates a huge volume of data to record
- See the Cable Setup page which shows how the Odroids are connected to the Beast and the Airspy
- See the Configuration Data page which has the Hardware, Firmware and Software Configuration Data

Cable Setup



Configuration Data



Beast hardware version 1.1 with Firmware 1.42-019

Airspy Original with Firmware NOS v1.0.0-rc5-0-g648c14f 2015-05-20

Mini-Circuits Splitter ZAPD-2-S+

Mini-Circuits Filter VBFZ-1065-S+

Antenna DPD Productions ADS-B Vertical Outdoor Base Antenna

Antenna to Filter cable is a 40 foot Bury-FLEX Low-Loss Coax

Same length, manufacturer and type of cable used to connect the Splitter with the Beast and Airspy (RG402 Coax – 15 cm)

Odroid U3 – modemixer2 - v.20150628

Odroid XU4 – modedeco2 - v.20150628

Beast Configuration

- The Beast is connected to an Odroid U3 via a USB 2.0 port on the Odroid
- The Odroid U3 has modesmixer2 running which reads the Mode S Frames from the Beast, forwards the data to decodeadsb and provides graphical and textual metrics regarding the data
- The Odroid U3 has decodeadsb running which reads data from modesmixer2 , records the Mode S frames, forwards the data to Plane Plotter and calculates metrics regarding the data

Airspy Configuration

- The Airspy is connected to an Odroid XU4 via a USB 3.0 port on the Odroid
- The Odroid XU4 has modesdeco2 running which decodes the digital signals into Mode S Frames, forwards the data to decodeadsb and provides graphical and textual metrics regarding the data
- The Odroid XU4 has decodeadsb running which reads data from modesdeco2, records the Mode S frames, forwards the data to Plane Plotter and calculates metrics regarding the data

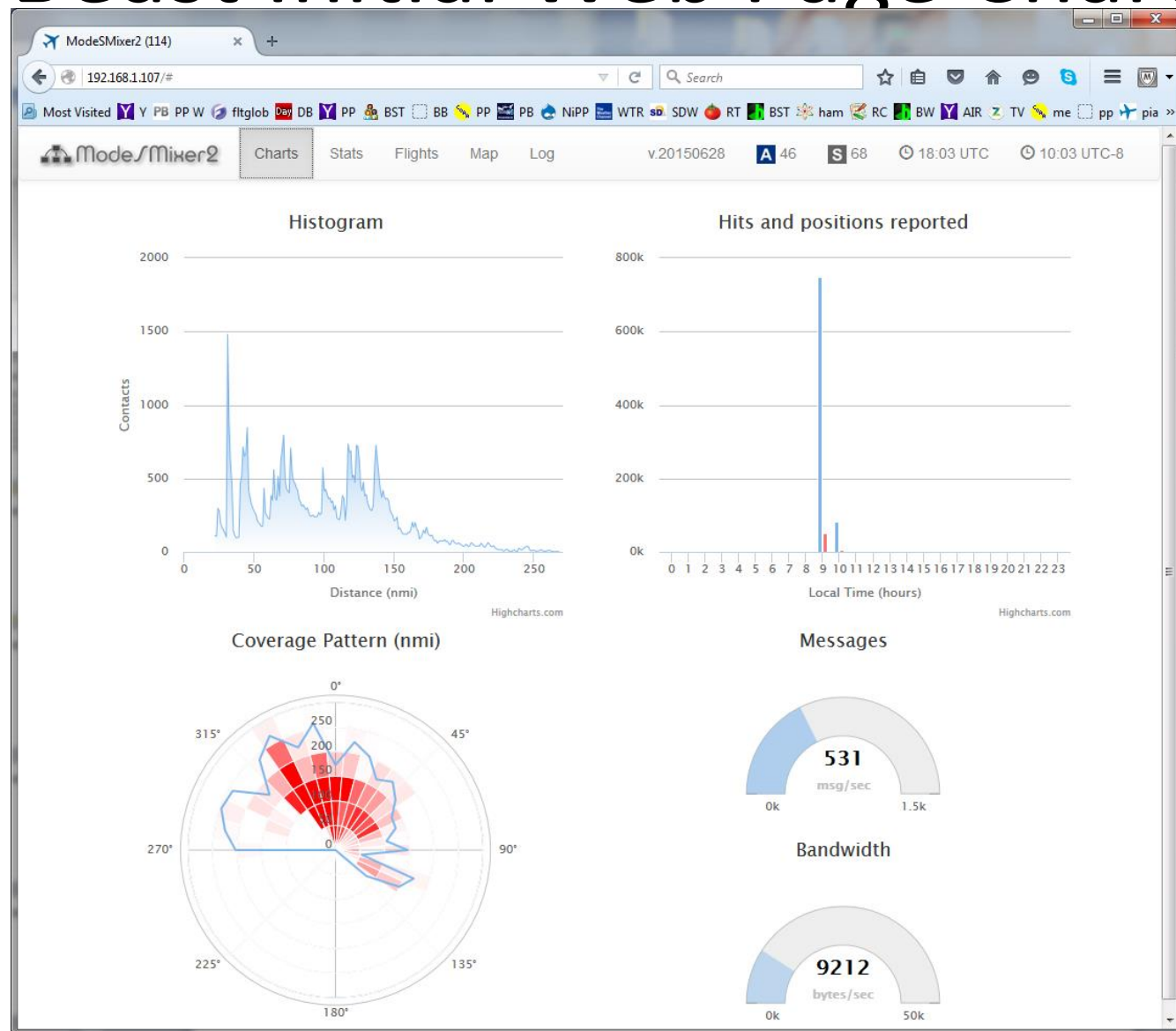
Starting the Beast and Airspy Test

- The Beast and the Airspy are started by a “hand” using a telnet session and start within 2 seconds of each other
- The logs from decodeadsb confirm this:
 - Beast Program Start Time = GMT Time = Sunday November 29, 2015 17:41:39.369
 - Airspy Program Start Time = GMT Time = Sunday November 29, 2015 17:41:38.630
- With the software starting almost simultaneously, the metrics can be easily compared
- Screen shots are recorded within a few seconds of each other so that the data can be easily compared as well

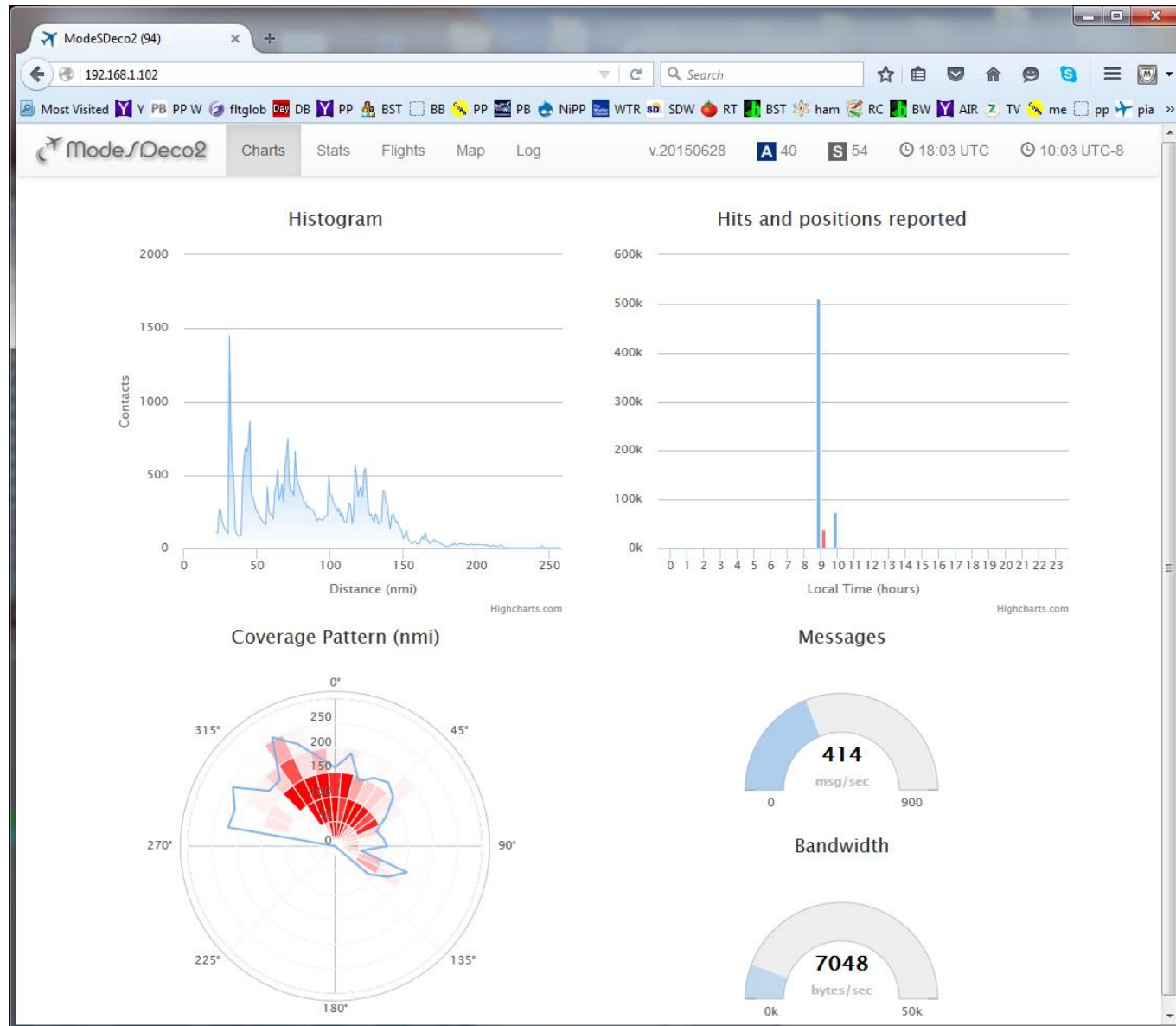
During the Test

- Screen shots are taken, from both the Beast and Airspy, showing:
 - The graphical and textual metrics from modedeco2 / modemixer2
 - Plane Plotter display
 - Odroid Processor Utilization Rates
 - decodeadsb running metrics

Beast Initial Web Page Chart



Airspy Initial Web Page Chart



Beast Initial Web Page Stats

ModeS Mixer2 (116)

192.168.1.107/#

Most Visited Y Y PB PP W fitglob Day DB Y PP BST BB PP PB NiPP WTR SDW RT BST ham RC BW Y AIR TV me pp pia >>

ModeS Mixer2 Charts **Stats** Flights Map Log v.20150628 A 46 S 70 18:03 UTC 10:03 UTC-8

Total		Mode S			ADS-B		Mode A/C
Messages	Bytes	Total	Long	Short	Total	Positions	Total
881369	15222524	738514	5447	733067	142855	59820	

DF	Messages	Description
0	337998	SHORT AIR-AIR SURVEILLANCE (ACAS)
4	89664	SURVEILLANCE ALTITUDE REPLY
5	2708	SURVEILLANCE IDENTITY REPLY
11	301579	ALL-CALL REPLY
16	13	LONG AIR-AIR SURVEILLANCE (ACAS)
17	137390	EXTENDED SQUITTER (ADS-B)
18	5284	EXTENDED SQUITTER/SUPPLEMENTARY
20	4264	COMM-B ALTITUDE REPLY
21	1160	COMM-B IDENTITY REPLY

DF Subtype	Messages	Description
0	17	No position information
2	5268	Aircraft ID Cat. C
4	6539	Aircraft ID Cat. A
7	549	Surface, RC < 75.0 m or RC < 185.2 m
8	3	Surface, RC > 185.2 m or unknown
10	2110	Airborne, RC < 25 m and VPL < 37.5 m
11	53371	Airborne, RC < 75 m and VPL < 112 m or RC < 185.2 m
12	3931	Airborne, RC < 370.4 m
18	1071	Airborne, RC > 37.04 km or unknown
19	62901	Airborne velocity
23	141	Test message
28	853	TCAS Status
29	3556	Status information
31	2364	Aircraft operational status

Format	Count
No position information	17
None	141
Aircraft operational status	2370
Surface position	552
Aircraft status	853
Identification and category	11824
Target state and status	3562
Airborne Velocity	62984
Airborne position	60552

Name	Value
Start Time	2015-11-29 09:41:19

Airspy Initial Web Page Stats

ModeSDeco2 (92) x +

192.168.1.102/#

Search

Most Visited Y PB PP W fitglob DB PP BST BB PP PB NiPP WTR SDW RT BST ham RC BW AIR TV me pp pia >>

ModeSDeco2 Charts Stats Flights Map Log v.20150628 A 38 S 54 18:03 UTC 10:03 UTC-8

Total		Mode S			ADS-B		Mode A/C
Messages	Bytes	Total	Long	Short	Total	Positions	Total
590448	10113048	486645	3576	483069	103803	43601	

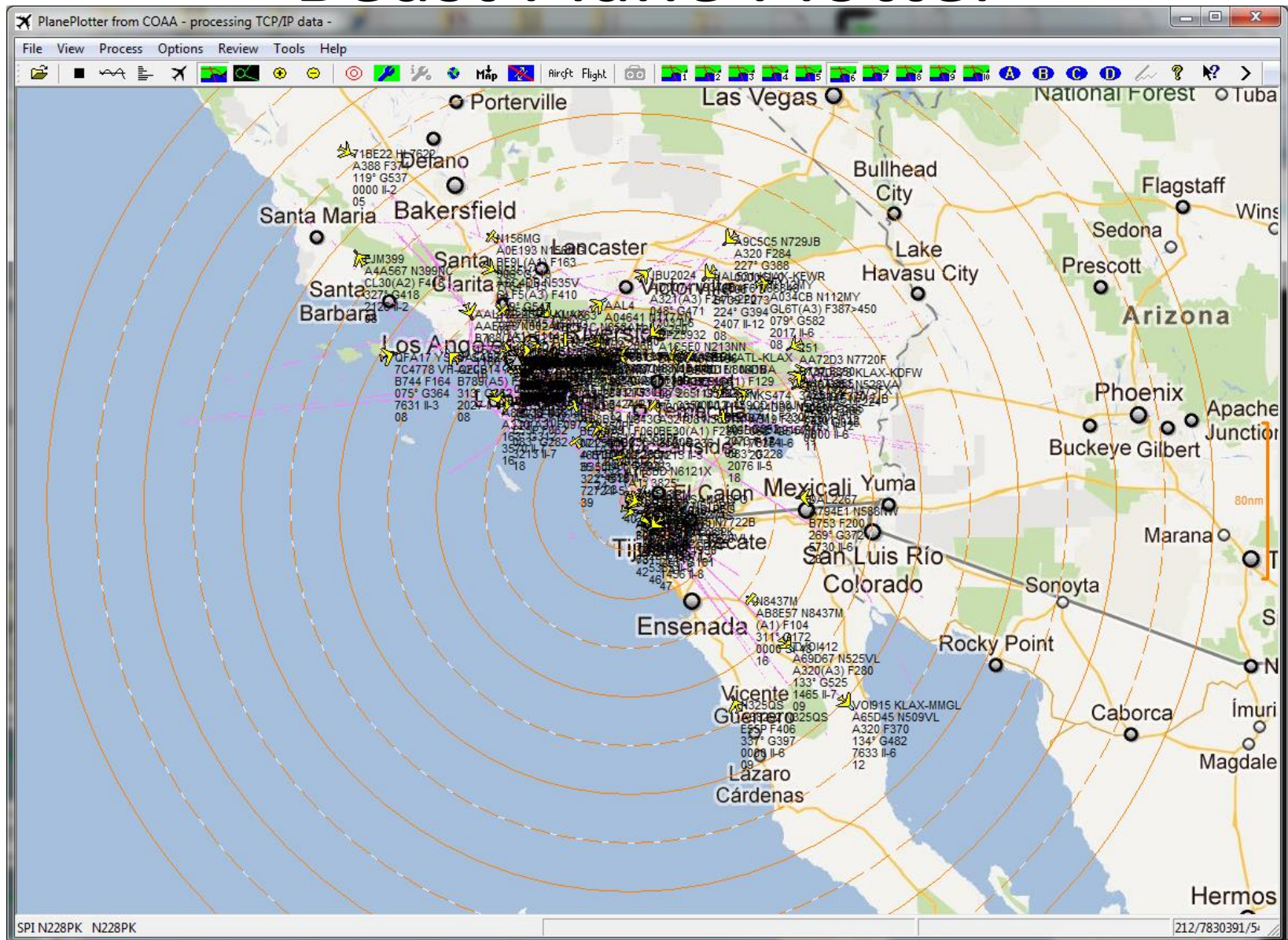
DF	Messages	Description
0	228534	SHORT AIR-AIR SURVEILLANCE (ACAS)
4	65633	SURVEILLANCE ALTITUDE REPLY
5	2197	SURVEILLANCE IDENTITY REPLY
11	185901	ALL-CALL REPLY
16	369	LONG AIR-AIR SURVEILLANCE (ACAS)
17	98504	EXTENDED SQUITTER (ADS-B)
18	5166	EXTENDED SQUITTER/SUPPLEMENTARY
20	2661	COMM-B ALTITUDE REPLY
21	532	COMM-B IDENTITY REPLY

DF Subtype	Messages	Description
0	1	No position information
2	5150	Aircraft ID Cat. C
3	1	Aircraft ID Cat. B
4	4781	Aircraft ID Cat. A
7	579	Surface, RC < 75.0 m or RC < 185.2 m
8	4	Surface, RC > 185.2 m or unknown
10	904	Airborne, RC < 25 m and VPL < 37.5 m
11	40020	Airborne, RC < 75 m and VPL < 112 m or RC < 185.2 m
12	2548	Airborne, RC < 370.4 m
18	667	Airborne, RC > 37.04 km or unknown
19	45309	Airborne velocity
23	65	Test message
28	440	TCAS Status
29	1951	Status information
31	1251	Aircraft operational status

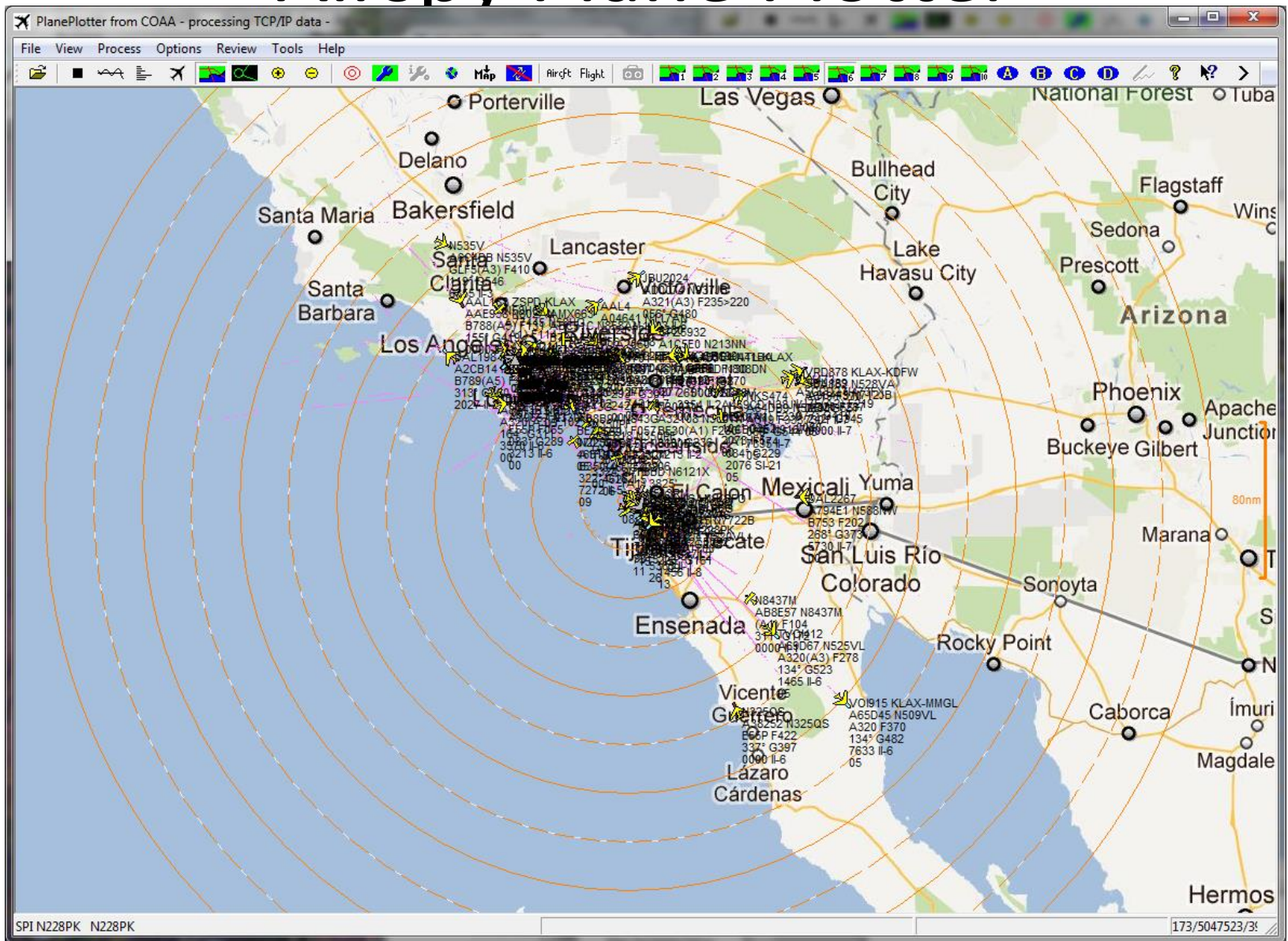
Format	Count
No position information	1
None	65
Aircraft operational status	1253
Surface position	583
Aircraft status	440
Target state and status	1954
Identification and category	9948
Airborne Velocity	45365
Airborne position	44194

Name	Value
Start Time	2015-11-29 09:41:18

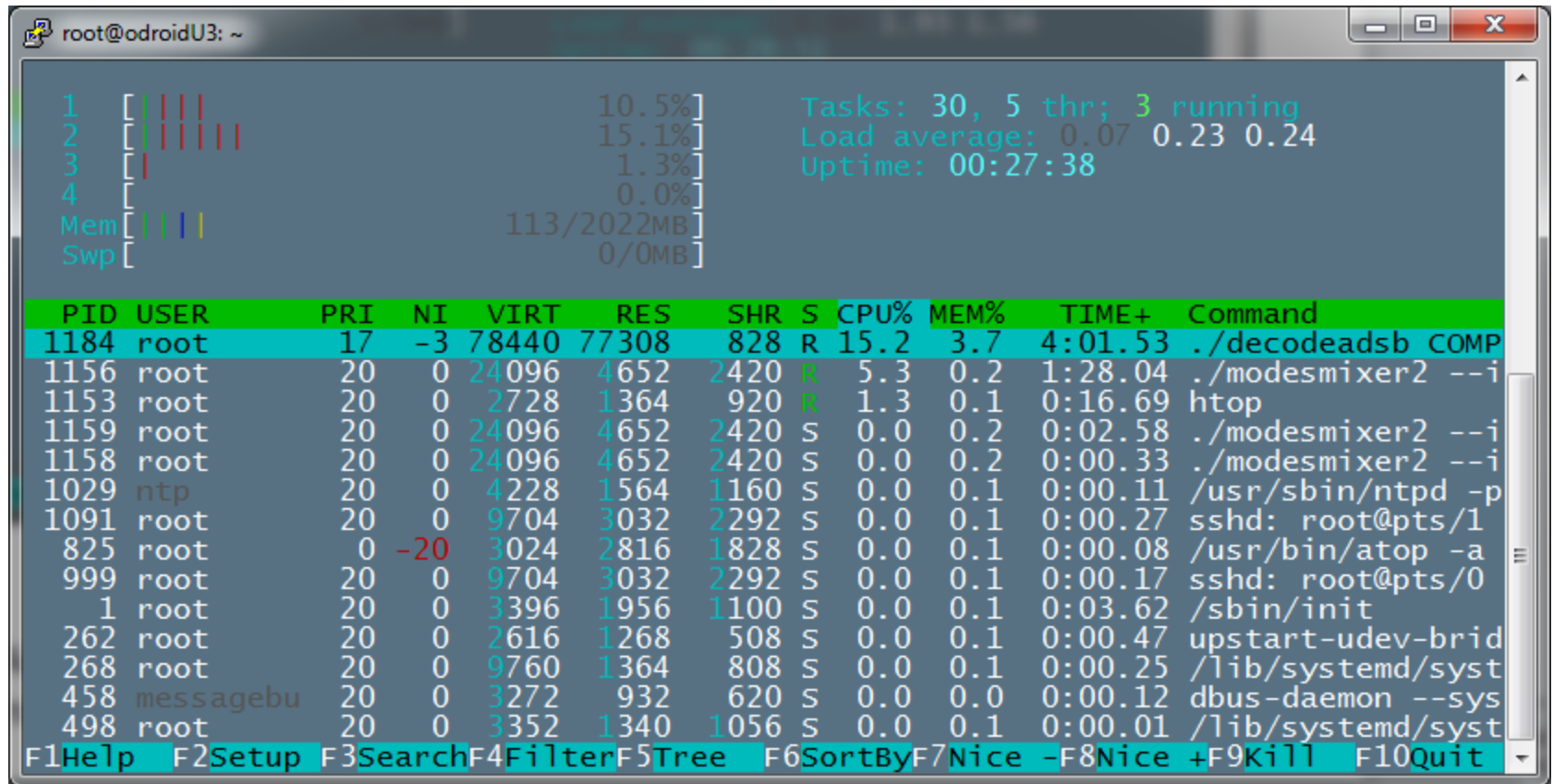
Beast Plane Plotter



Airspy Plane Plotter

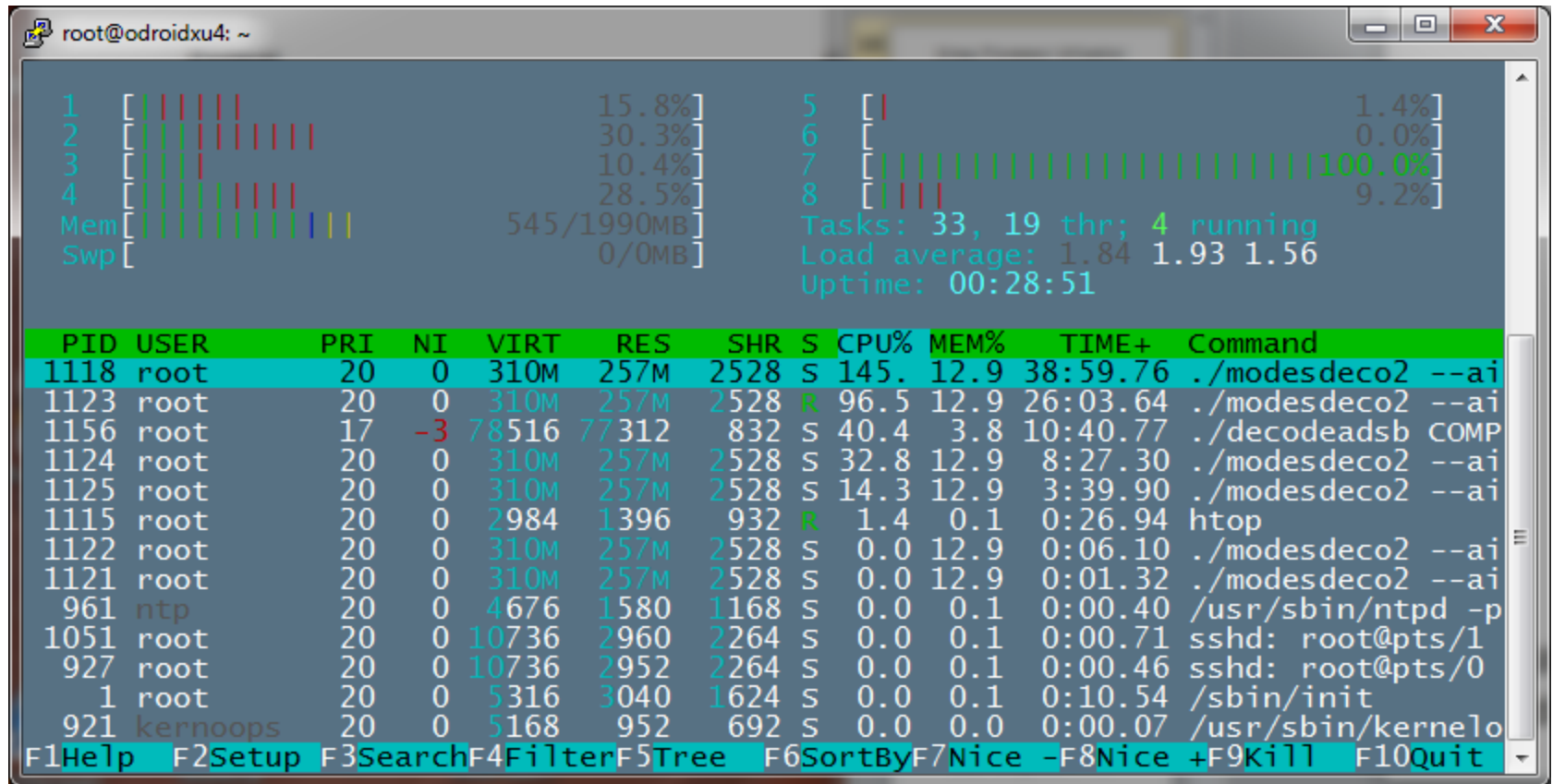


Beast Processor Utilization



With the Beast, the CPU utilization is very low because the Beast processes the digital signals into Mode S Frames.

Airspy Processor Utilization



With the Airspy, the CPU utilization is very high because the CPU processes the digital signals into Mode S Frames.

Beast decodeadsb Metrics

```
root@odroidU3: ~/modesdeco2mixer2
Total # Mode S Frames = 5261044, Total # Good Mode S Frames = 5156555
Time of metrics (GMT seconds) = 1448825982, Operating for 0000:01:58:00 (dddd:hh:mm:ss)
777777
Metrics Averages (bytes/sec): Entire Test Period: 12780, This interval: 12782
Minimum interval value: 10453, Maximum interval value: 15143
Aircraft Records Metrics: Total ARs = 4000, Used ARs = 181, Free ARs = 3819, Max Used ARs = 269
Current CPU % = 17, Max CPU % = 20, MIN CPU % = 14
Metrics Averages (Mode A/C Frames/sec): This interval: 0
Minimum interval value: 0, Maximum interval value: 0
Metrics Averages (Short + Long Mode S Frames/sec): This interval: 743
Minimum interval value: 595, Maximum interval value: 899
Metrics Averages (DF=17 ADS-B Frames/sec): This interval: 103
Minimum interval value: 61, Maximum interval value: 152
Metrics Averages (DF=18 TIS-B/ADS-R Frames/sec): This interval: 7
Minimum interval value: 4, Maximum interval value: 57
Metrics Averages (Good (Same as PP) Mode S Frames/sec): This interval: 733
Minimum interval value: 572, Maximum interval value: 849
% Mode S Good Frames: 98%, Overall % Mode S Good Frames: 98%
Total # Mode S Frames = 5305689, Total # Good Mode S Frames = 5200541
Time of metrics (GMT seconds) = 1448826042, Operating for 0000:01:59:00 (dddd:hh:mm:ss)
```

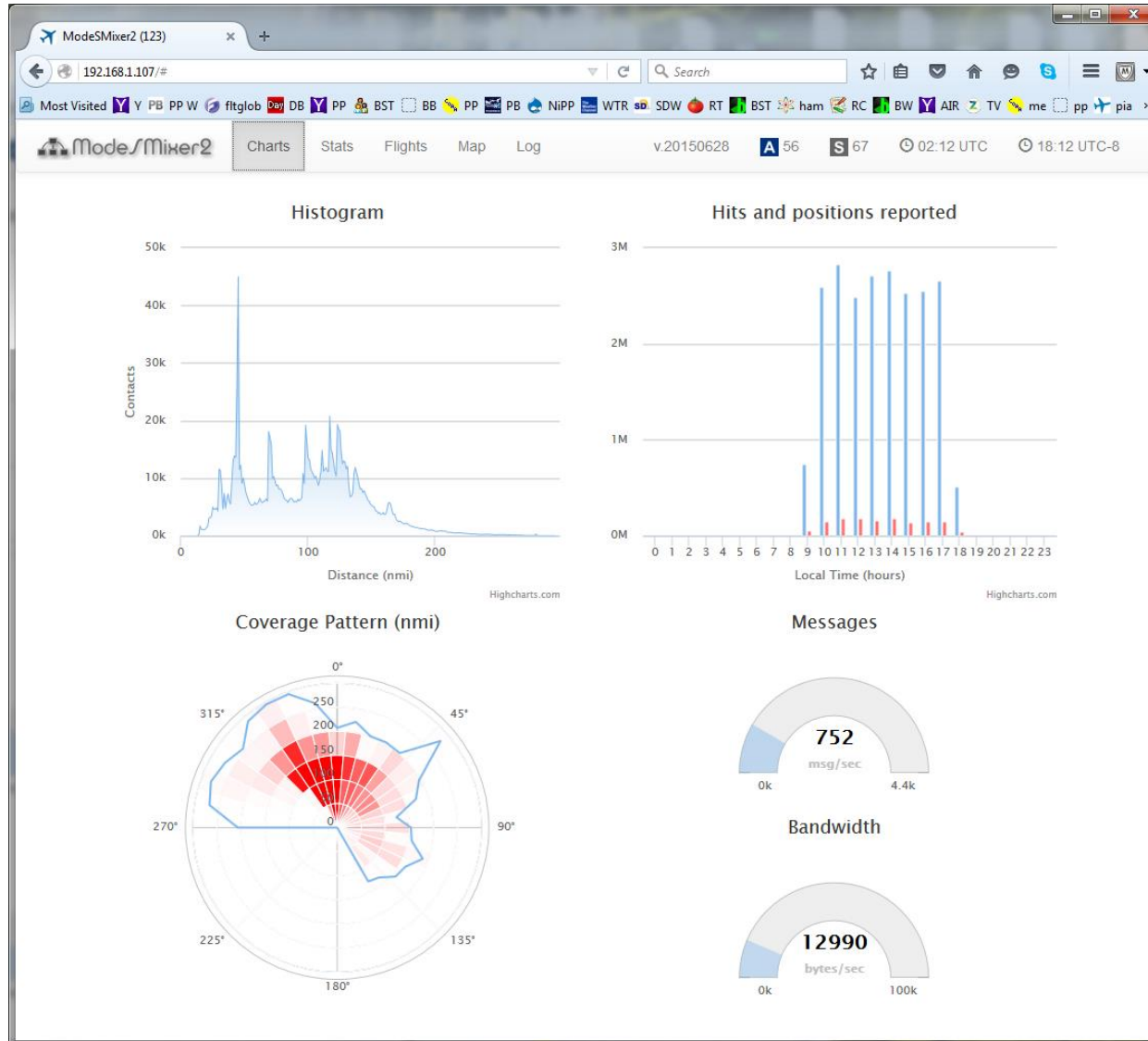
Airspy decodeadsb Metrics

```
root@odroidxu4: ~/modesdeco2mixer2
Total # Mode S Frames = 3428410, Total # Good Mode S Frames = 3323804
Time of metrics (GMT seconds) = 1448825981, Operating for 0000:01:58:00 (dddd:hh:mm:ss)
777777
Metrics Averages (bytes/sec): Entire Test Period: 8395, This interval: 8238
Minimum interval value: 6450, Maximum interval value: 10178
Aircraft Records Metrics: Total ARs = 4000, Used ARs = 144, Free ARs = 3856, Max Used ARs = 232
Current CPU % = 42, Max CPU % = 46, MIN CPU % = 39
Metrics Averages (Mode A/C Frames/sec): This interval: 0
Minimum interval value: 0, Maximum interval value: 0
Metrics Averages (Short + Long Mode S Frames/sec): This interval: 476
Minimum interval value: 368, Maximum interval value: 610
Metrics Averages (DF=17 ADS-B Frames/sec): This interval: 70
Minimum interval value: 41, Maximum interval value: 111
Metrics Averages (DF=18 TIS-B/ADS-R Frames/sec): This interval: 6
Minimum interval value: 3, Maximum interval value: 54
Metrics Averages (Good (Same as PP) Mode S Frames/sec): This interval: 466
Minimum interval value: 359, Maximum interval value: 555
% Mode S Good Frames: 97%, Overall % Mode S Good Frames: 96%
Total # Mode S Frames = 3457043, Total # Good Mode S Frames = 3351776
Time of metrics (GMT seconds) = 1448826041, Operating for 0000:01:59:00 (dddd:hh:mm:ss)
```

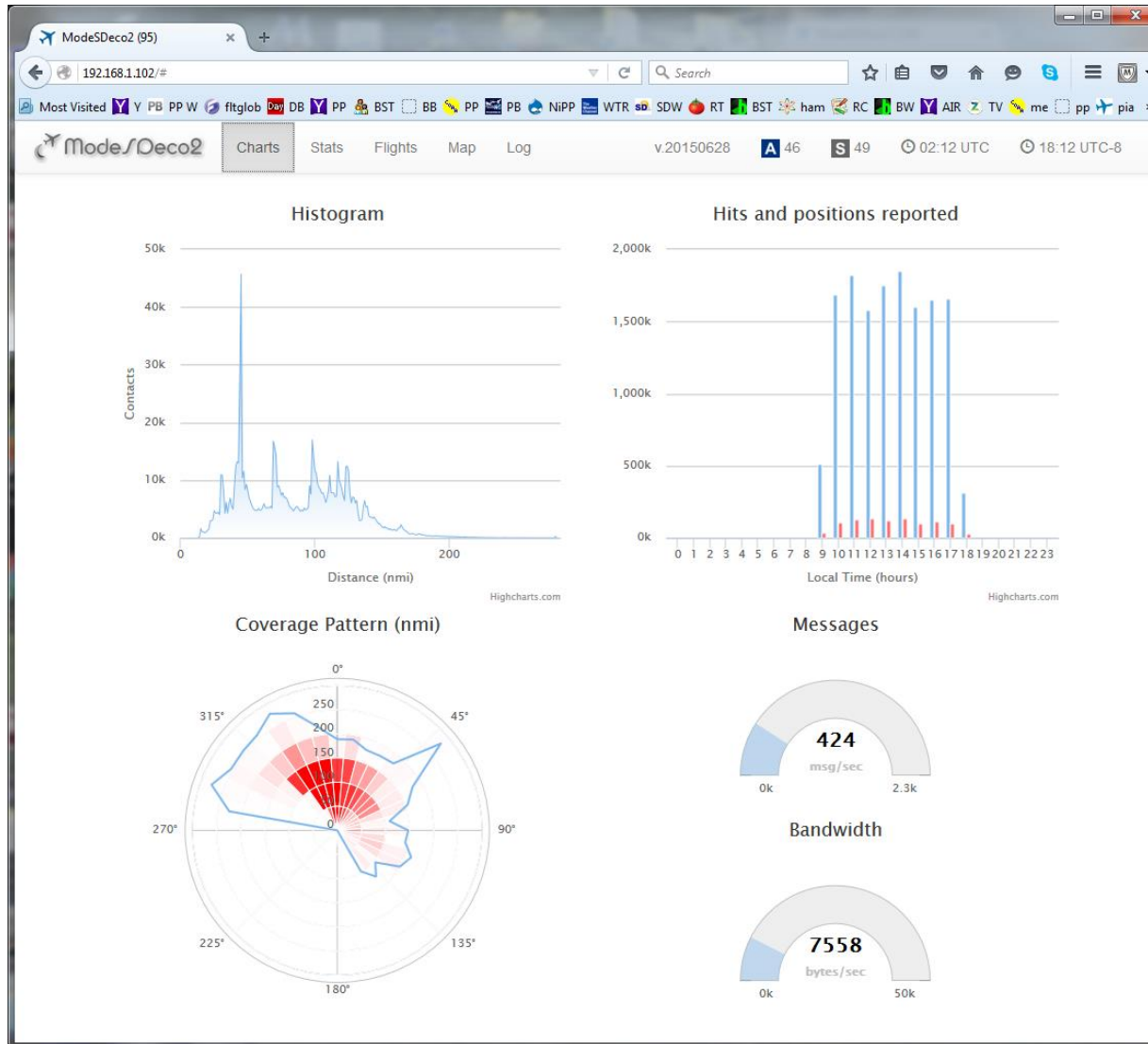
After the Test

- Screen shots are taken, from both the Beast and Airspy, showing:
 - The graphical and textual metrics from modedeco2 / modemixer2
 - decodeadsb running metrics and final metrics
- After the test, the data recorded by decodeadsb is then
 - Plotted using Google Earth which graphically shows all of the recorded flights
 - Plotted using gnuplot which graphically shows Mode S and ADS-B metrics

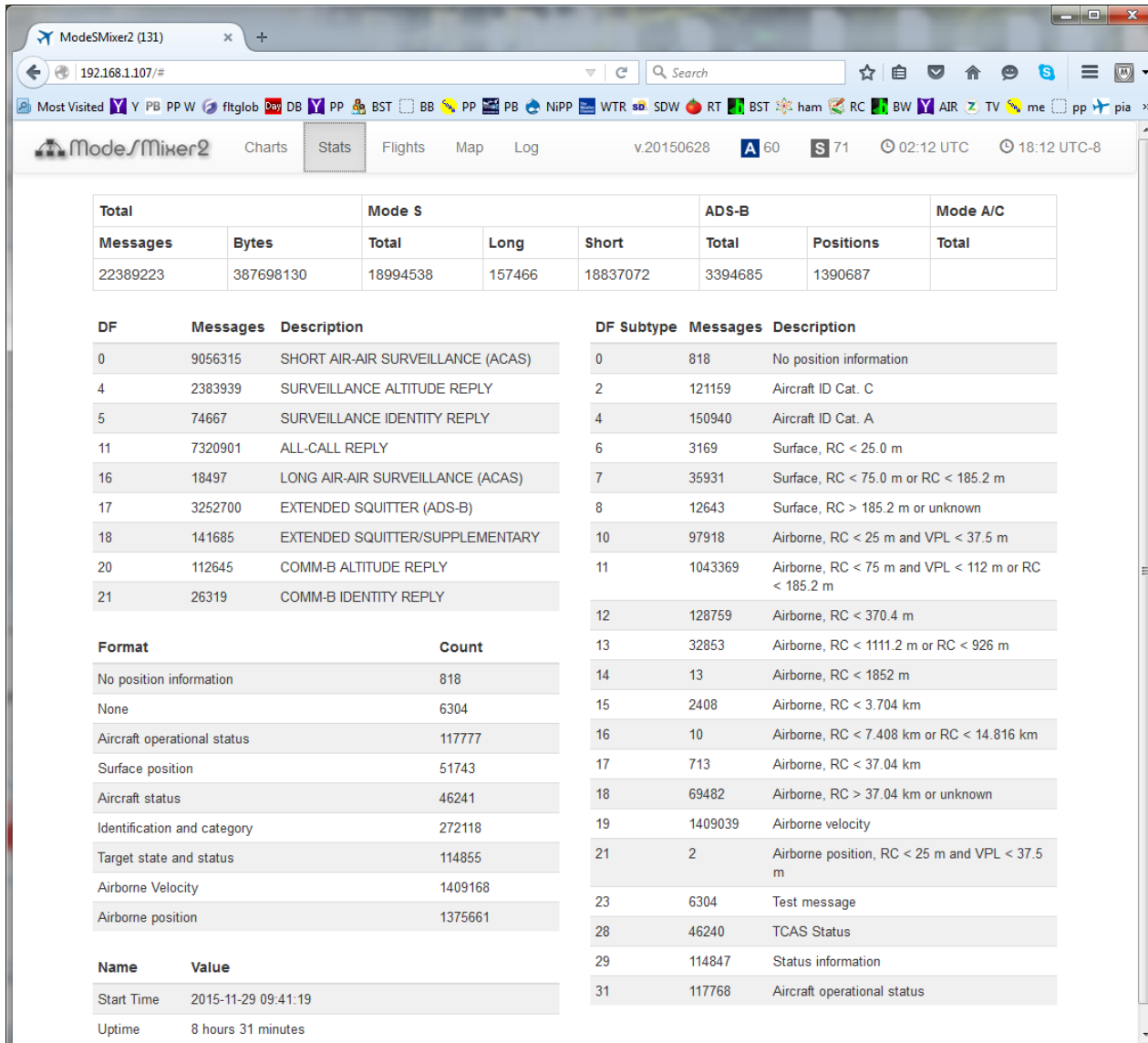
Beast Final Web Page Chart



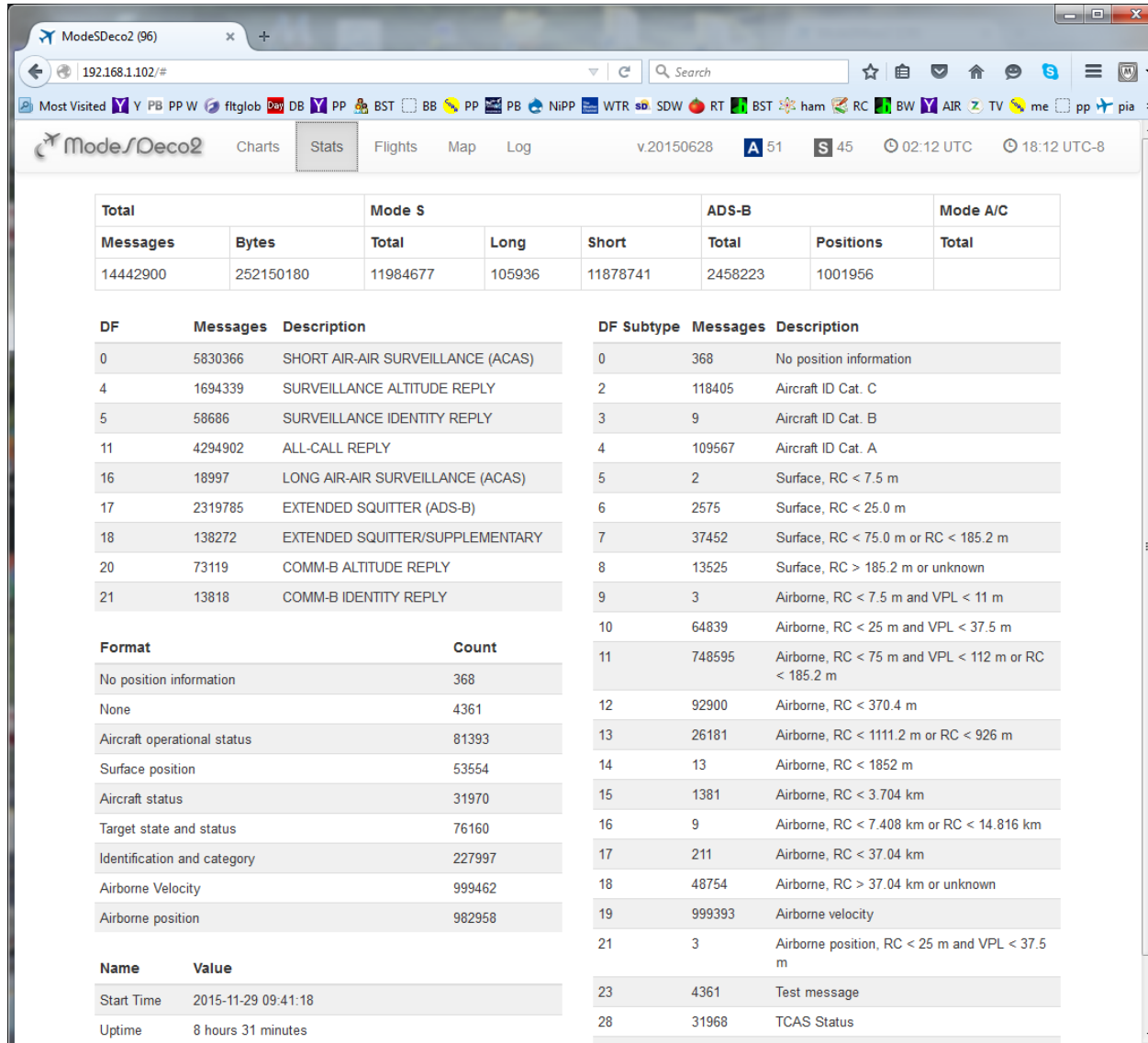
Airspy Final Web Page Chart



Beast Final Web Page Stats



Airspy Final Web Page Stats



Beast Metrics – First Set

```
root@odroidU3: /dev/shm
Metrics Averages (bytes/sec): Entire Test Period: 12651, This interval: 12983
Minimum interval value: 9847, Maximum interval value: 15154
Aircraft Records Metrics: Total ARs = 4000, Used ARs = 141, Free ARs = 3859, Max
Used ARs = 269
Current CPU % = 17, Max CPU % = 20, MIN CPU % = 13
Metrics Averages (Mode A/C Frames/sec): This interval: 0
Minimum interval value: 0, Maximum interval value: 0
Metrics Averages (Short + Long Mode S Frames/sec): This interval: 748
Minimum interval value: 544, Maximum interval value: 954
Metrics Averages (DF=17 ADS-B Frames/sec): This interval: 129
Minimum interval value: 57, Maximum interval value: 152
Metrics Averages (DF=18 TIS-B/ADS-R Frames/sec): This interval: 4
Minimum interval value: 4, Maximum interval value: 57
Metrics Averages (Good (Same as PP) Mode S Frames/sec): This interval: 736
Minimum interval value: 563, Maximum interval value: 867
% Mode S Good Frames: 98%, Overall % Mode S Good Frames: 98%
Total # Mode S Frames = 22659206, Total # Good Mode S Frames = 22226996
Time of metrics (GMT seconds) = 1448849742, Operating for 0000:08:34:00 (dddd:hh
:mm:ss)
777

Terminating Program, signal = Terminated
```

Airspy Metrics – First Set

```
root@odroidxu4: /dev/shm
Metrics Averages (bytes/sec): Entire Test Period: 8229, This interval: 8644
Minimum interval value: 5771, Maximum interval value: 10473
Aircraft Records Metrics: Total ARs = 4000, Used ARs = 114, Free ARs = 3886, Max
Used ARs = 232
Current CPU % = 42, Max CPU % = 48, MIN CPU % = 35
Metrics Averages (Mode A/C Frames/sec): This interval: 0
Minimum interval value: 0, Maximum interval value: 0
Metrics Averages (Short + Long Mode S Frames/sec): This interval: 491
Minimum interval value: 313, Maximum interval value: 647
Metrics Averages (DF=17 ADS-B Frames/sec): This interval: 100
Minimum interval value: 35, Maximum interval value: 121
Metrics Averages (DF=18 TIS-B/ADS-R Frames/sec): This interval: 4
Minimum interval value: 3, Maximum interval value: 54
Metrics Averages (Good (Same as PP) Mode S Frames/sec): This interval: 479
Minimum interval value: 326, Maximum interval value: 586
% Mode S Good Frames: 97%, Overall % Mode S Good Frames: 97%
Total # Mode S Frames = 14635344, Total # Good Mode S Frames = 14203135
Time of metrics (GMT seconds) = 1448849741, Operating for 0000:08:34:00 (dddd:hh
:mm:ss)
777

Terminating Program, signal = Terminated
```

Beast Metrics – Second Set

```
root@odroidU3: /dev/shm
```

DF Metrics

- # Discarded due to a major decoding error (wrong frame size, CRC error)
- # Filtered Out due to DF filtering or the Quick Filter
- # Recorded is the total amount recorded
- # Recorded (with) Errors have minor decoding errors (fields with illegal values, can't locate 24-bit ICAO) kept mostly to later examine for a decodeadsb software error or in case the 24-bit ICAO is later proved to be valid
- # Recorded OK means kept without any errors at all

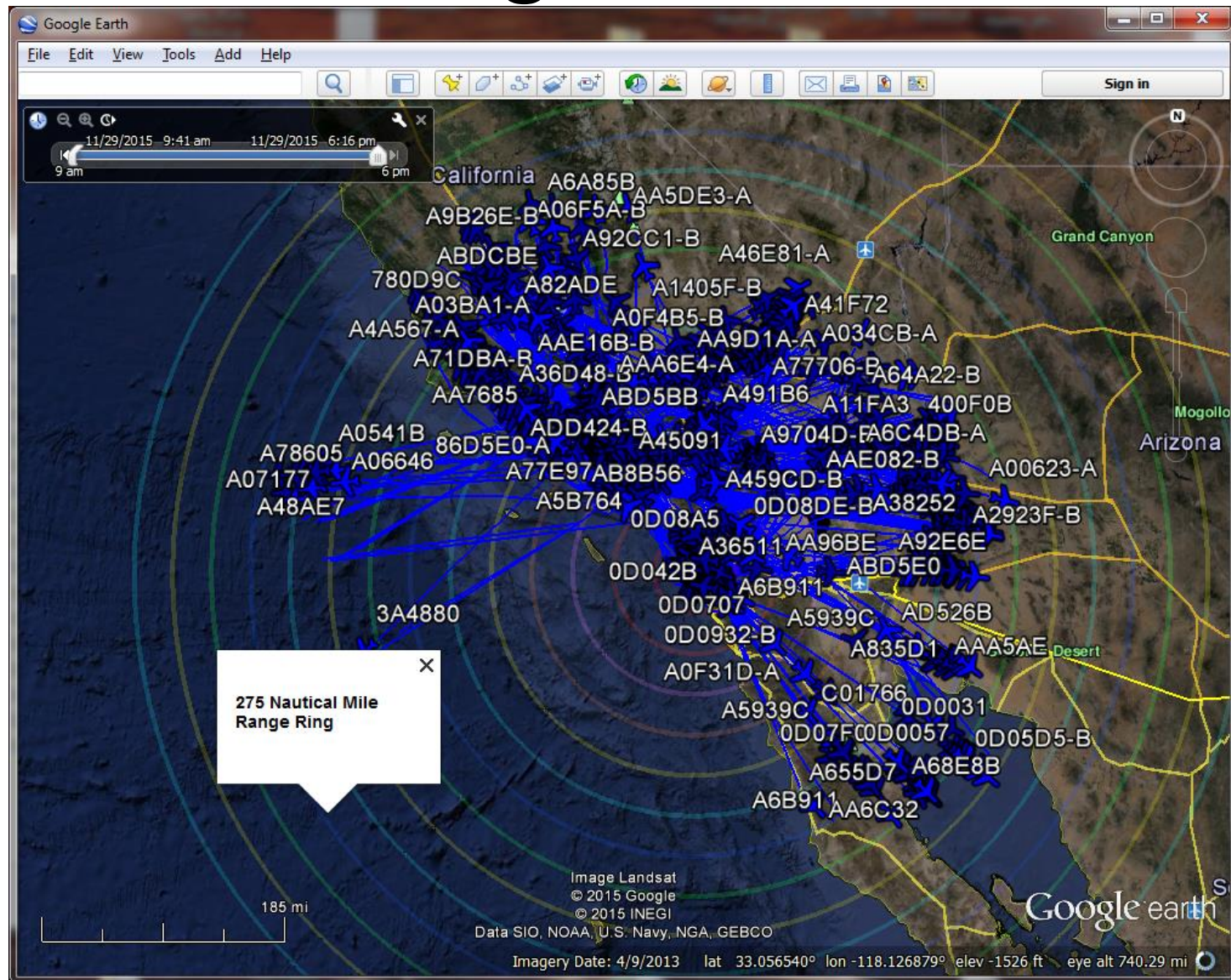
DF	# Received	# Discarded	# Filtered Out	# Recorded	# Recorded Errors	# Recorded OK	# Check Count
0	9121384	76987	0	9044397	0	9044397	9121384
4	2399649	14733	0	2384916	0	2384916	2399649
5	75167	757	0	74410	0	74410	75167
11	7374084	217237	0	7156847	0	7156847	7374084
16	18552	2922	0	15630	0	15630	18552
17	3281087	2787	0	3278300	0	3278300	3281087
18	269714	5456	0	264258	0	264258	269714
20	113237	897	0	112340	94650	17690	113237
21	26441	287	0	26154	15725	10429	26441

Airspy Metrics – Second Set

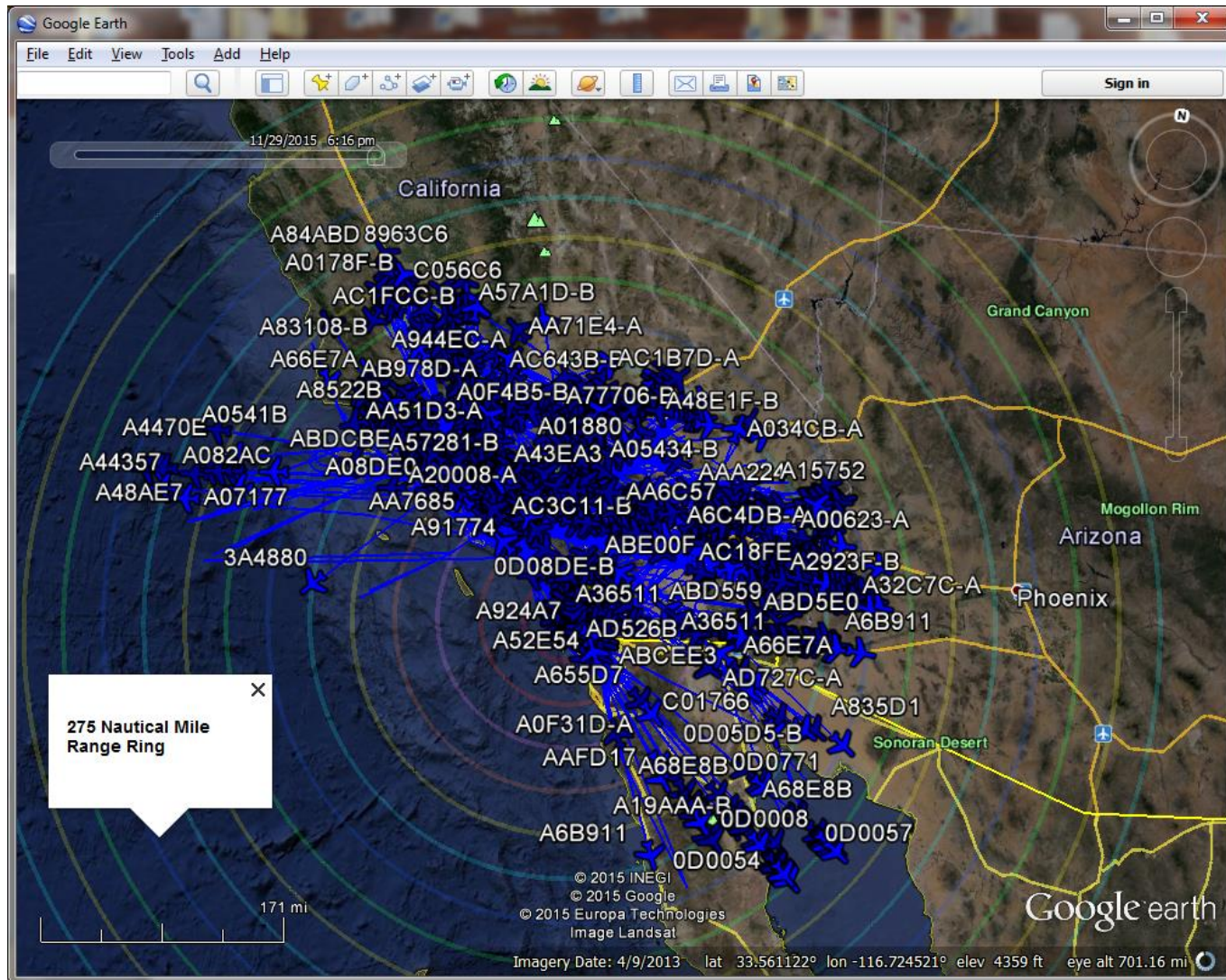
```
root@odroidxu4: /dev/shm
DF Metrics
# Discarded due to a major decoding error (wrong frame size, CRC error)
# Filtered Out due to DF filtering or the Quick Filter
# Recorded is the total amount recorded
# Recorded (with) Errors have minor decoding errors
  (fields with illegal values, can't locate 24-bit ICAO)
  kept mostly to later examine for a decodeadsb software error
  or in case the 24-bit ICAO is later proved to be valid
# Recorded OK means kept without any errors at all
```

DF	#	Received	#Discarded	# Filtered Out	# Recorded	# Recorded Errors	# Recorded OK	# Check Count
0		5866921	82031	0	5784890	0	5784890	5866921
4		1704314	18737	0	1685577	0	1685577	1704314
5		59047	895	0	58152	0	58152	59047
11		4325352	243251	0	4082101	0	4082101	4325352
16		19098	9632	0	9466	0	9466	19098
17		2341046	3196	0	2337850	0	2337850	2341046
18		245641	4410	0	241231	0	241231	245641
19		5	5	0	0	0	0	5
20		73505	902	0	72603	61036	11567	73505
21		13884	291	0	13593	8147	5446	13884

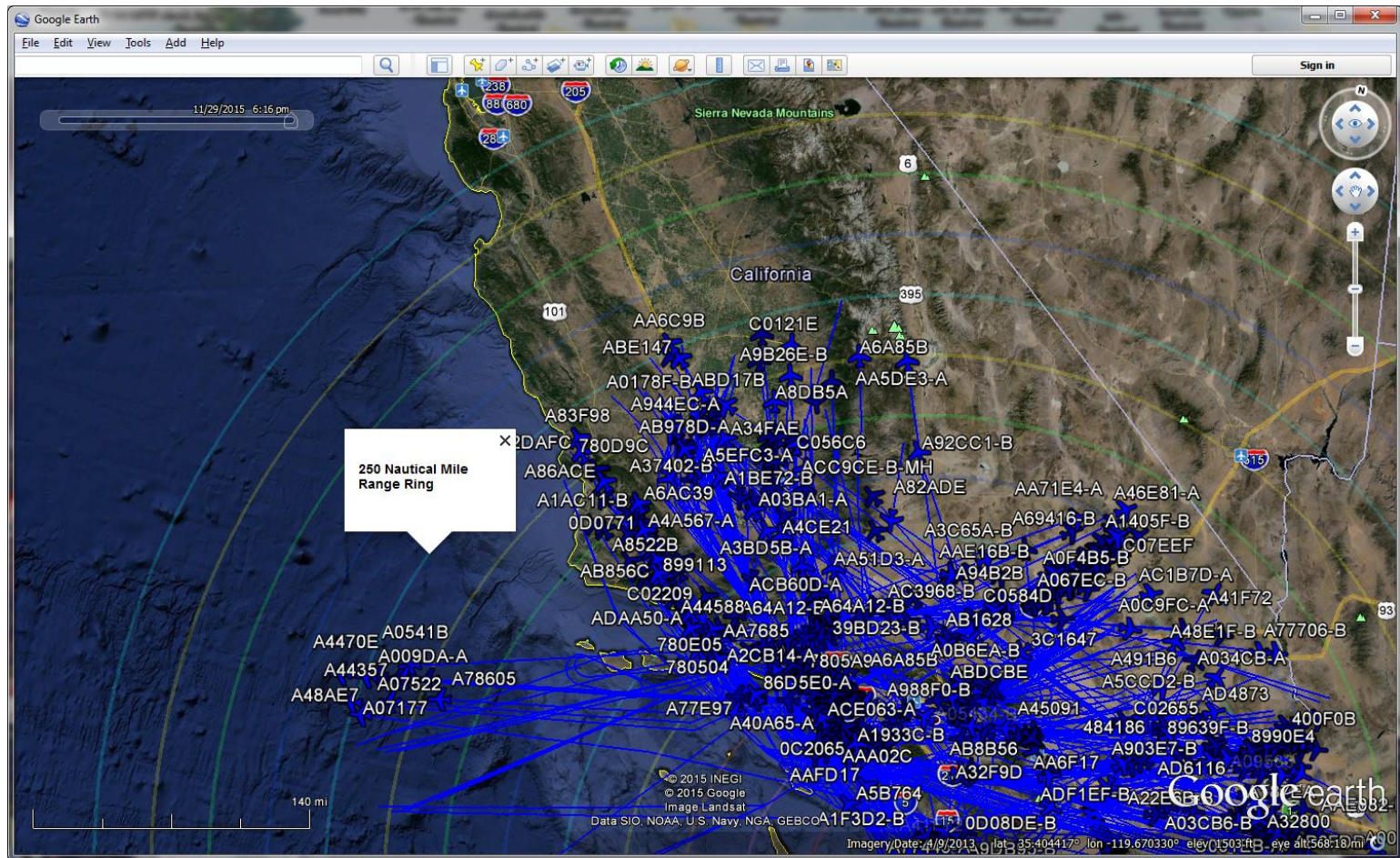
Beast Google Earth Plot #1



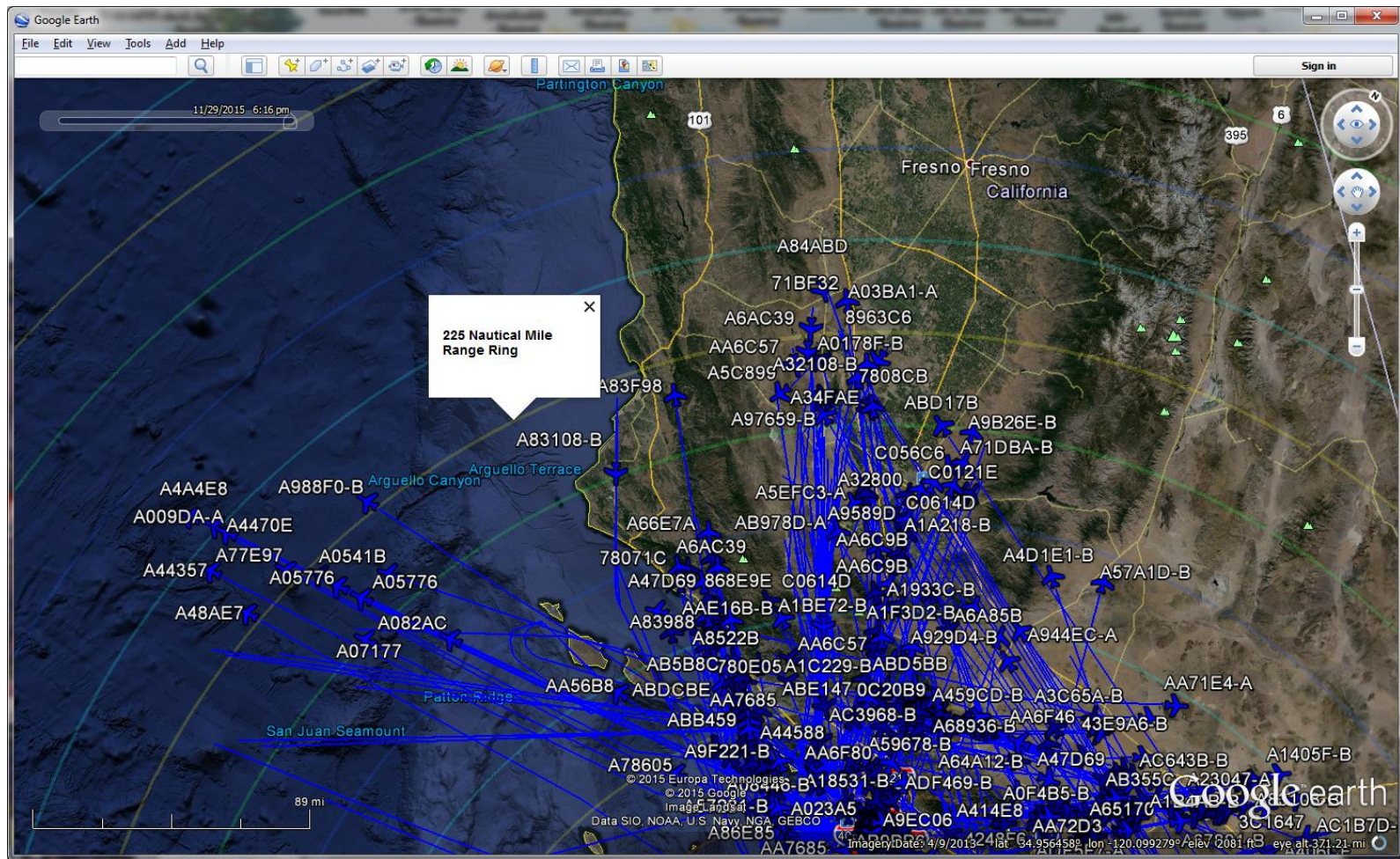
Airspy Google Earth Plot #1



Beast Google Earth Plot #2

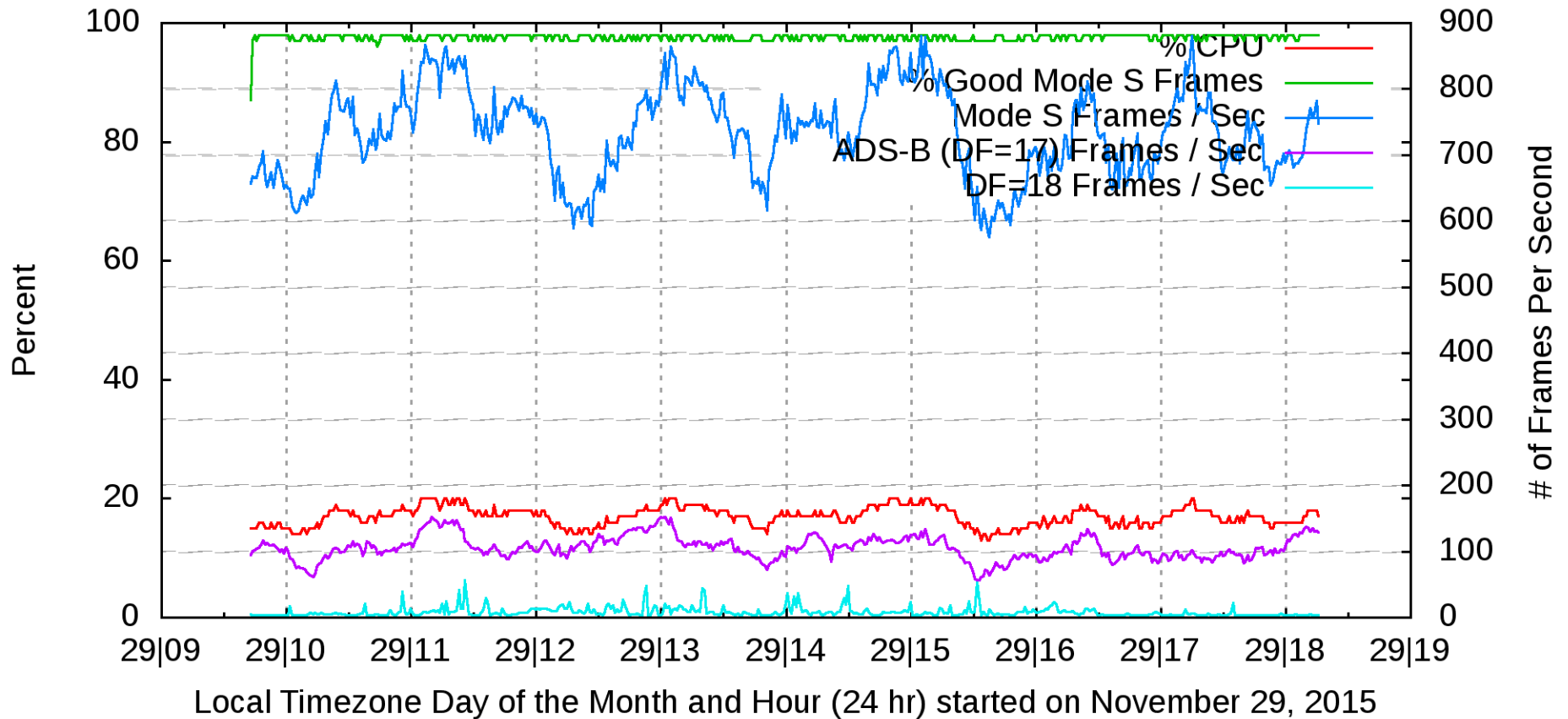


Airspy Google Earth Plot #2



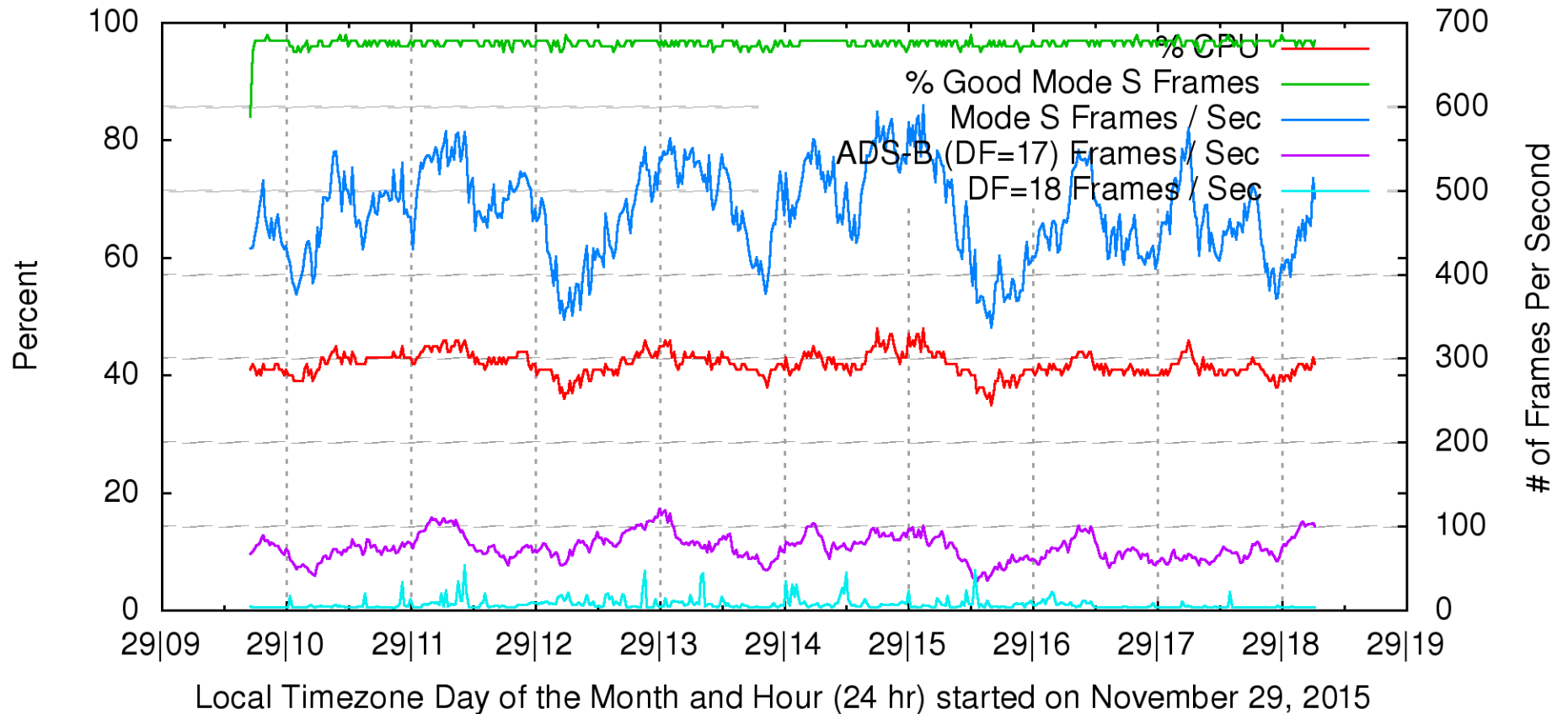
Beast Graph #1

151129beast Data - % CPU / % Good Mode S Frames VS Mode S / ADS-B (DF=17) / DF=18



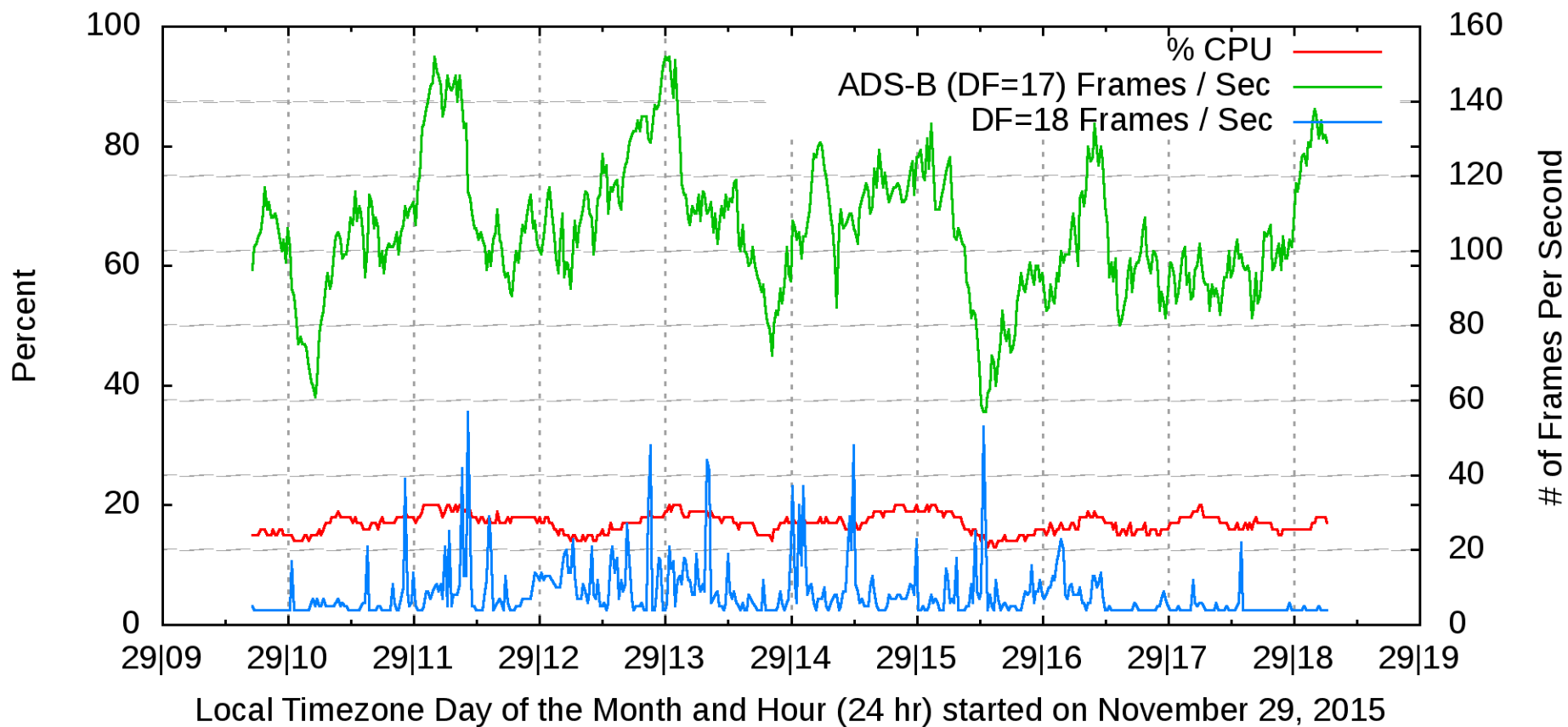
Airspy Graph #1

151129airspy Data - % CPU / % Good Mode S Frames VS Mode S / ADS-B (DF=17) / DF=18



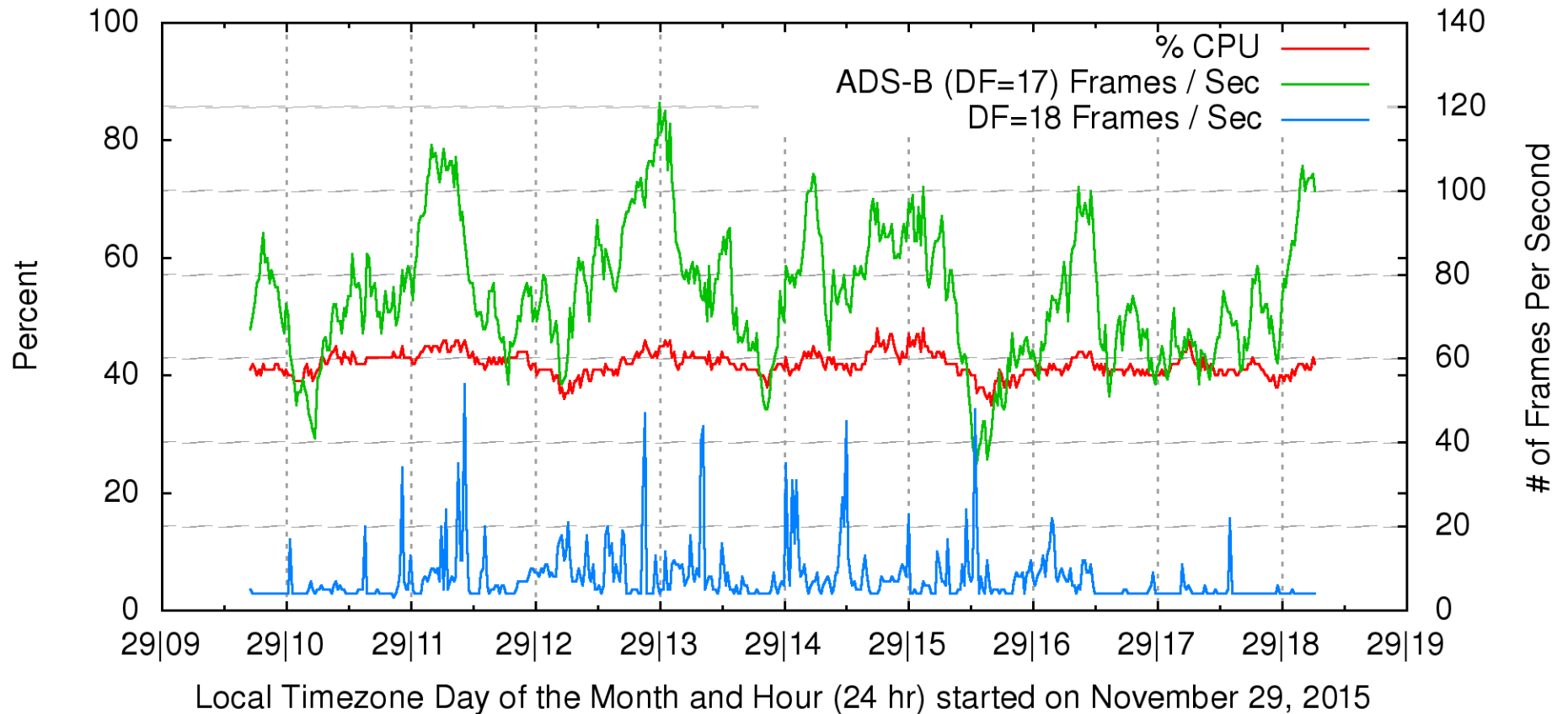
Beast Graph #2

151129beast Data - % CPU VS ADS-B (DF=17) / DF=18



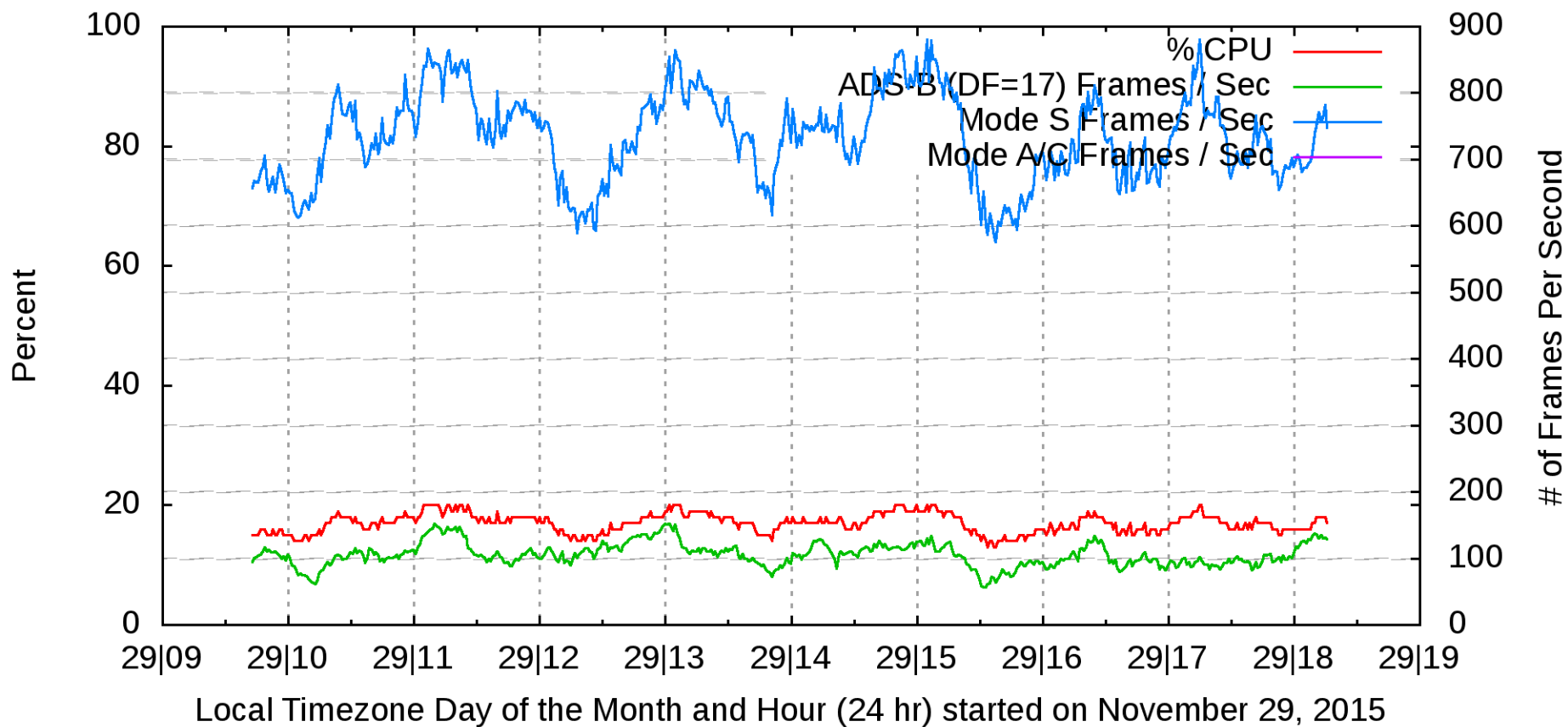
Airspy Graph #2

151129airspy Data - % CPU VS ADS-B (DF=17) / DF=18



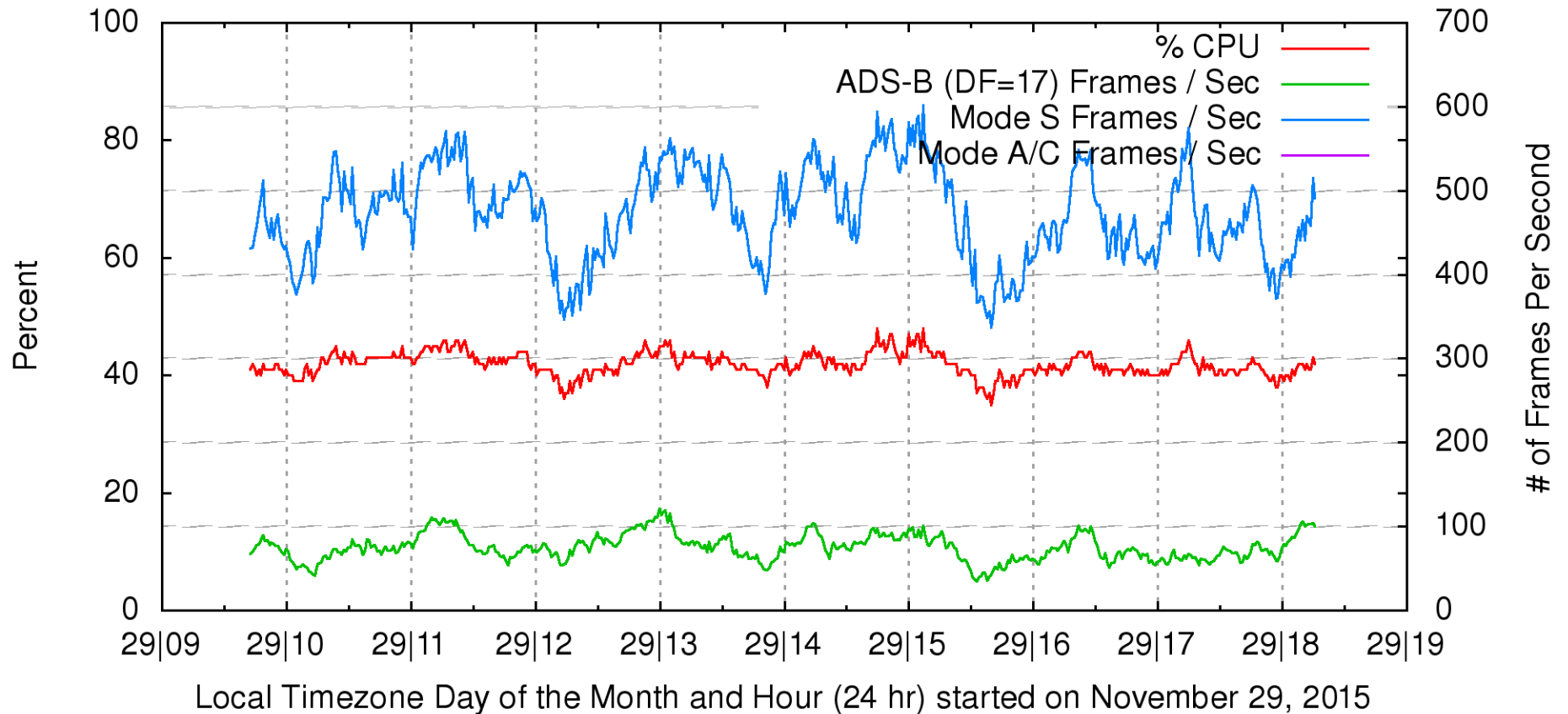
Beast Graph #3

151129beast Data - % CPU VS ADS-B (DF=17) / Mode S / Mode A/C



Airspy Graph #3

151129airspy Data - % CPU VS ADS-B (DF=17) / Mode S / Mode A/C



Beast System Cost

- The Beast costs 284 Euro Assembled = \$300
- It can be combined with a Raspberry Pi 2 (\$40) + microSD (\$12) + Case (\$10) + Power supply (\$10) for satisfactory performance (Total = \$72)
- Total cost = \$372
- The cost does NOT include the cost of an Antenna

Airspy System Cost

- The Airspy costs \$200
- It needs to be combined with a powerful multi-processor microprocessor such as an Odroid XU4 (\$76) + microSD (\$12) + Case (\$8) (Total = \$96)
- Total Cost = \$296
- The cost does NOT include the cost of an Antenna

RTL-SDR System Cost

- The RTL-SDR costs \$25
- Can combine with a Raspberry Pi 2 (\$40) + microSD (\$12) + Case (\$10) + Power supply (\$10) for satisfactory performance (Total = \$72)
- Total cost = \$97
- The cost does NOT include the cost of an Antenna

Beast – Summary Impression

- The Beast receives about 35% more Good Mode S Frames
- The Beast's Range is better (see Google Earth plots and modesdeco2/modesmixer2 charts)
- The cost difference is relatively small as the Beast System costs \$76 or 25% more than the Airspy System

Airspy – Summary Impression

- It is a good idea to buy an Airspy if you want to “spy” on a variety of RF frequencies and only want to periodically obtain ADS-B data
- Despite having a very powerful microprocessor performing the digital signals to Mode S Frames conversion, one of the processors was running at 98%
- Errors were sporadically logged by modesdeco2 that it lost data
- The Airspy is a good solution but the Beast is a much better solution for a dedicated ADS-B data receiver

Linux Computer Cost Comparisons

- Caveat:
 - I am not an employee of Odroid, they did not give me anything, they haven't paid me anything
- Raspberry Pi 2 (\$40) + microSD (\$12) + Case (\$10) + Power supply (\$10) (Total = \$72)
- Odroid XU4 comes with a power supply (\$76) + microSD (\$12) + Case (\$8) (Total = \$96)
- For \$24 more you get a computer running twice as fast with twice the number of processors
- I have several different Odroids (XU, XU3 Lite, XU4, C1, U2, U3) and all of them have been solid performers except for the C1
 - The only “problem child” was the C1 when it was first introduced as Odroid unsuccessfully tried to speed up the microSD
 - It took about 3 weeks for Odroid to fix the problem
 - Since the Odroid fixed the problem, it has done fine
- If you aren't using the Raspberry Pi I/O header then the Odroid is worth the extra \$24