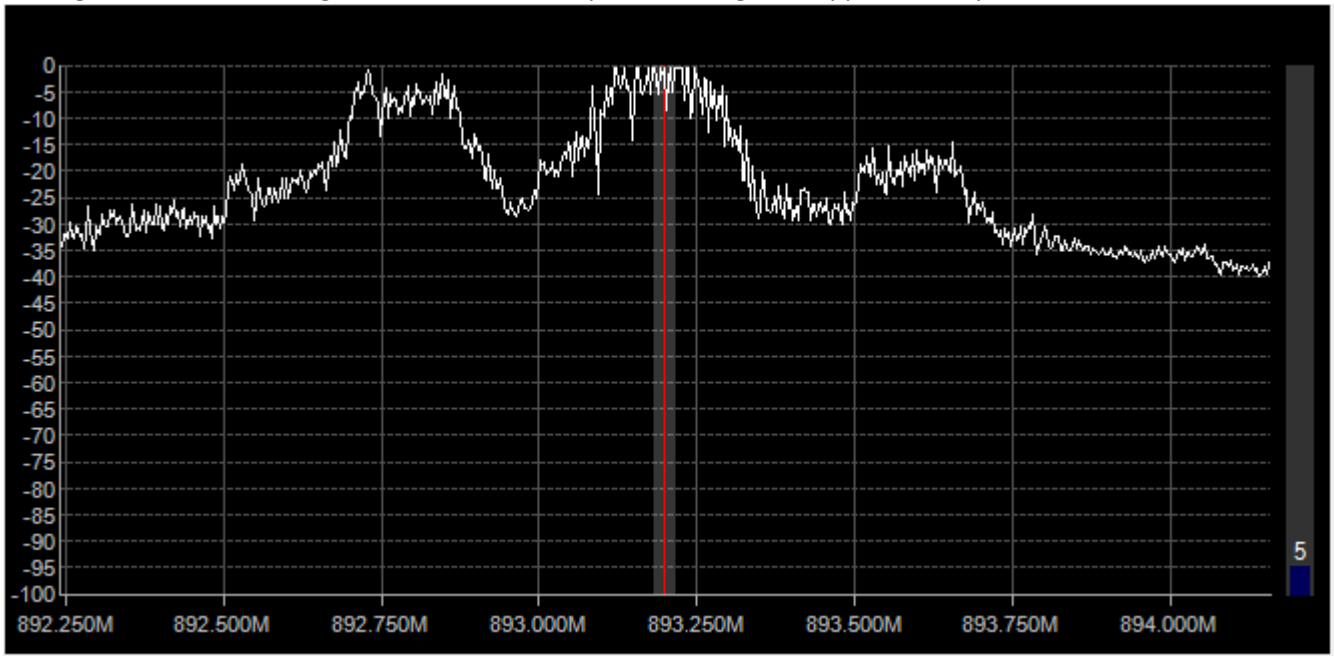
Disclaimer:
This document is intended to document and analyze the performance of the Open Source ADS-B Receiver (aka Stratux) Project. All data in this analysis was collected from the author's Open Source ADS-B Receiver Build. Due to variations in component selection and packaging of the Receiver project the performance of other Open Source ADS-B Receivers may differ from those of the author.

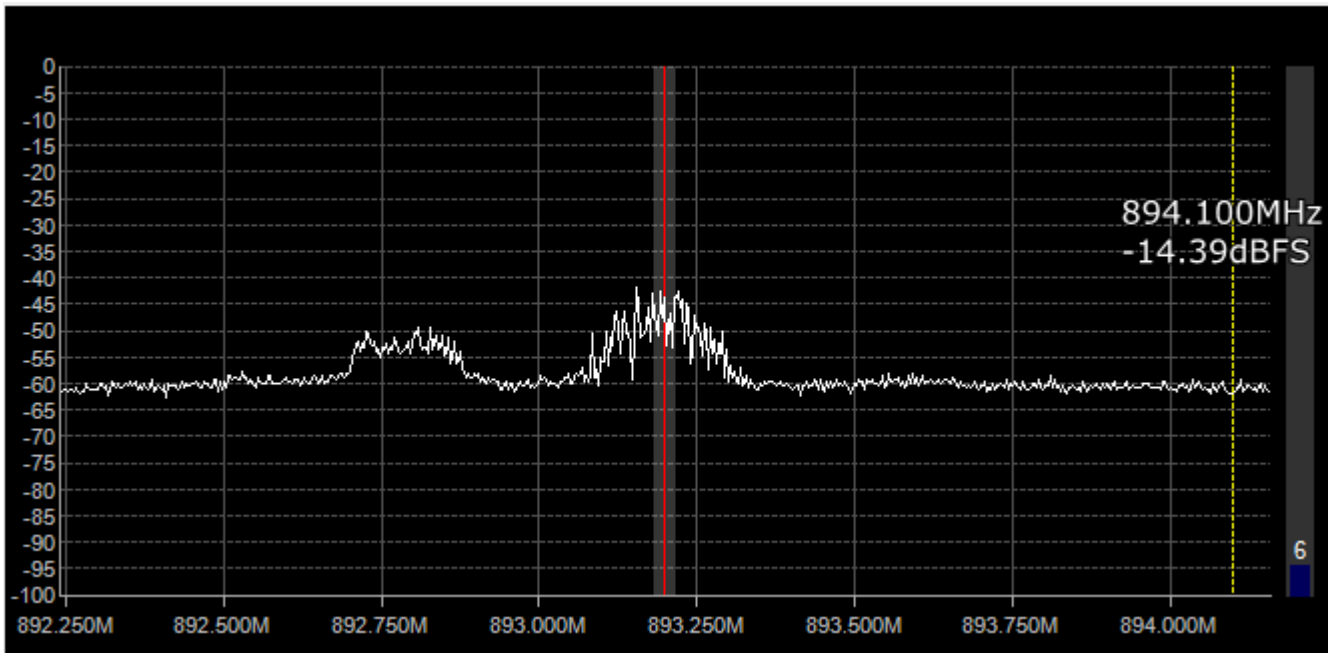
This a series of notes I took while testing the gain on a pair of Nano 2 SDRs.

I set up a Nano 2 running SDR# as a spectrum analyzer and monitored the GSM850 band. One thing I discovered is how much "junk" these devices receive when the gain is set to 48 dB. I am running a cell phone booster at my house and as a sanity check I turned it off and observed the GSM signal drops about 30 dB which correlates with the published gain of my booster. For each of these tests I am monitoring GSM850 channel 248 (893.2 MHz). The antenna is the dmurray14 High Gain 978 MHz antenna. The antenna was connected to the SDR via a 6" MCX to SMA pig tail.

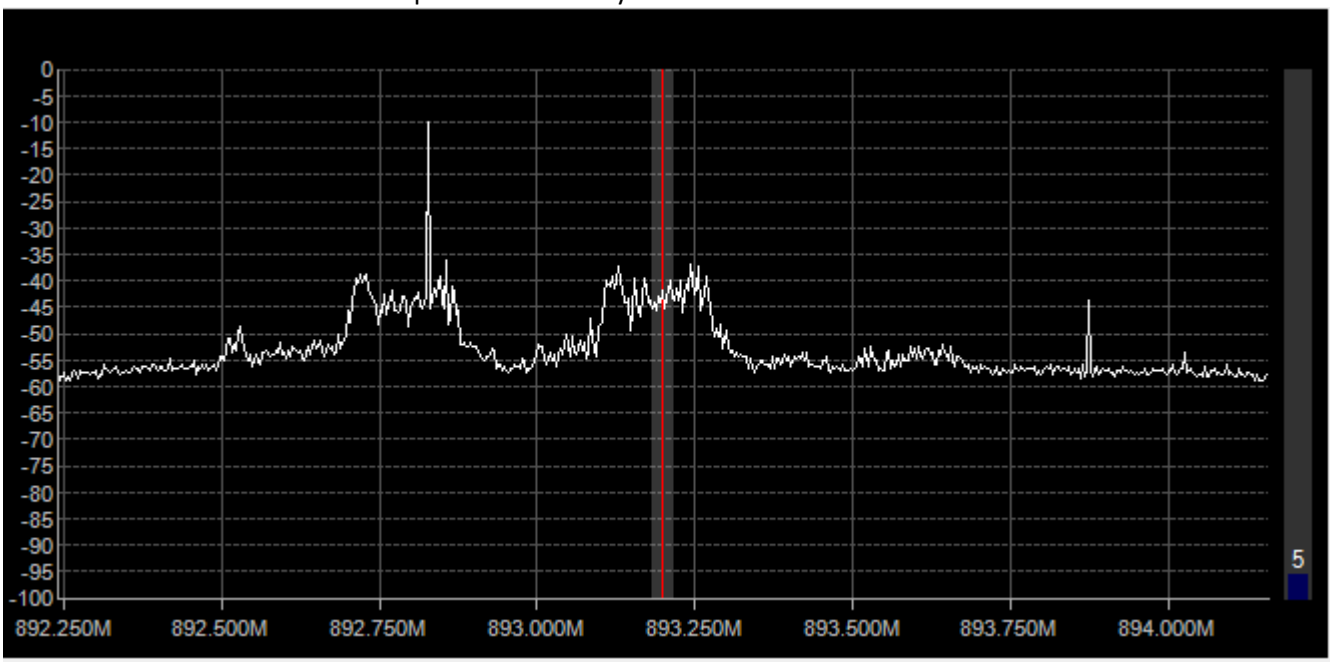
This figure is with the SDR gain set at 48 dB. The peak GSM signal is approximately -2.5 dBFS.



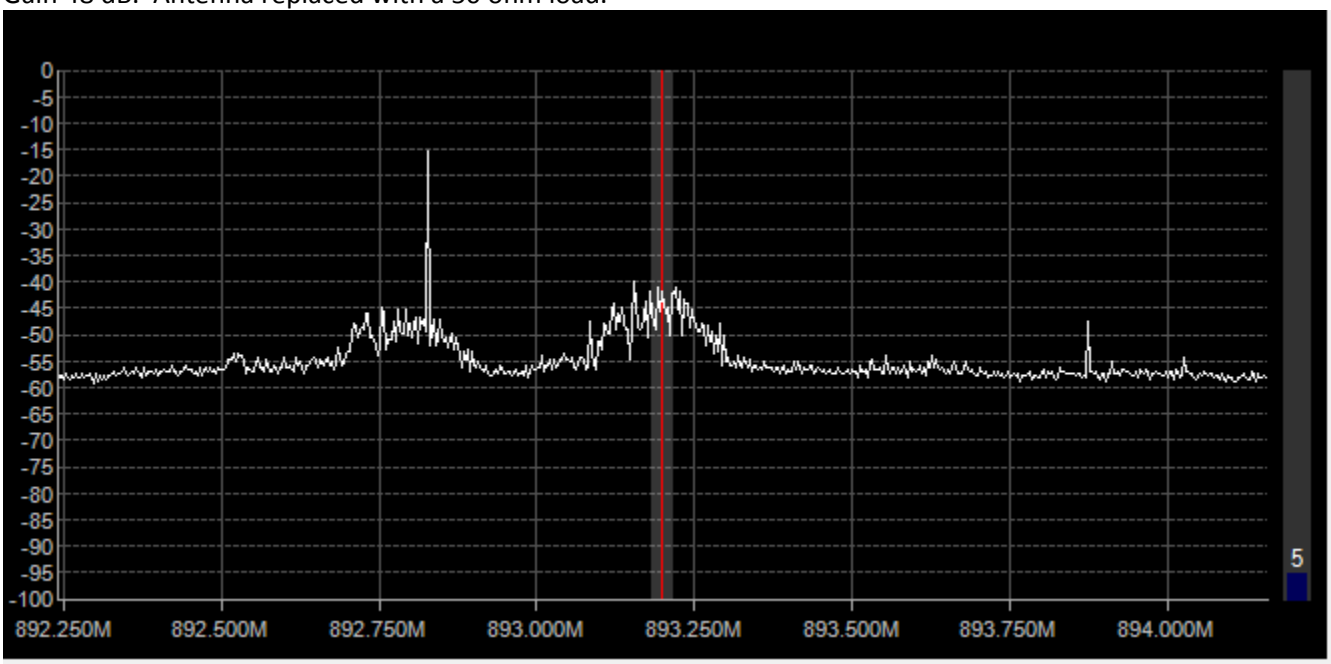
Same signal, Gain = 0 dB:
The signal level drops about 46 dB to 48 dB. This shows the receiver amplifier is not driven into compression at full gain with my cell booster.



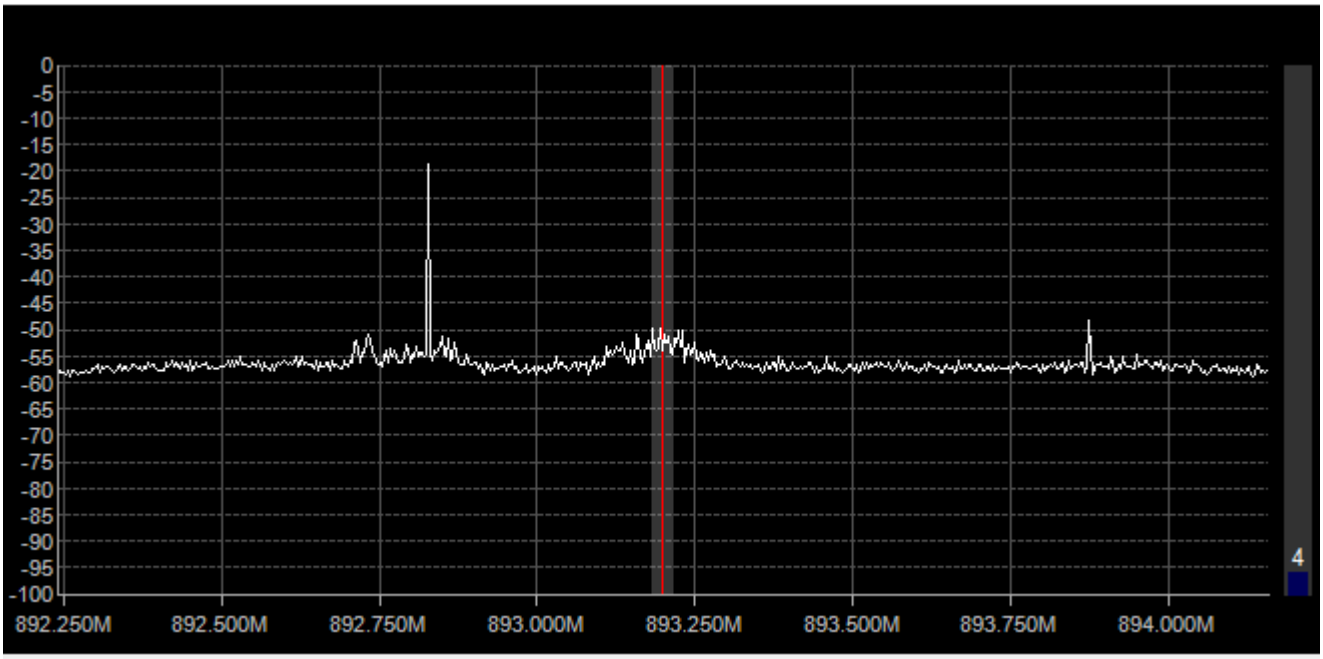
Gain 48 dB, Antenna disconnected from the pig tail.
Signal level dropped about 40 dB. The narrow spike to the right is a birdie (app. 892.830 MHz) from the SDR that is -10 dBFS. The birdie repeats about every



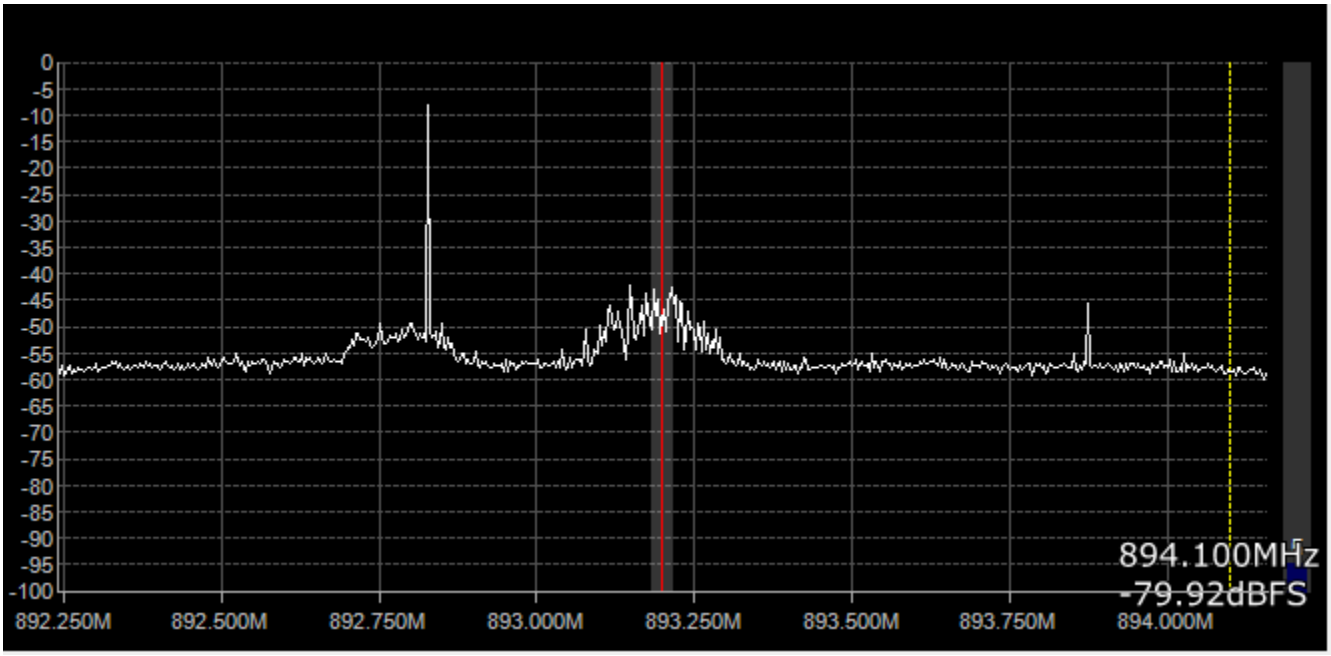
Gain 48 dB. Antenna replaced with a 50 ohm load.



Gain 48 dB, Antenna 50 ohm load, shield of aluminum foil around dongle. This is the best I could get with a crude shield around the dongle. Even with the shield, the GSM signal is still about 5 dB above the noise floor.

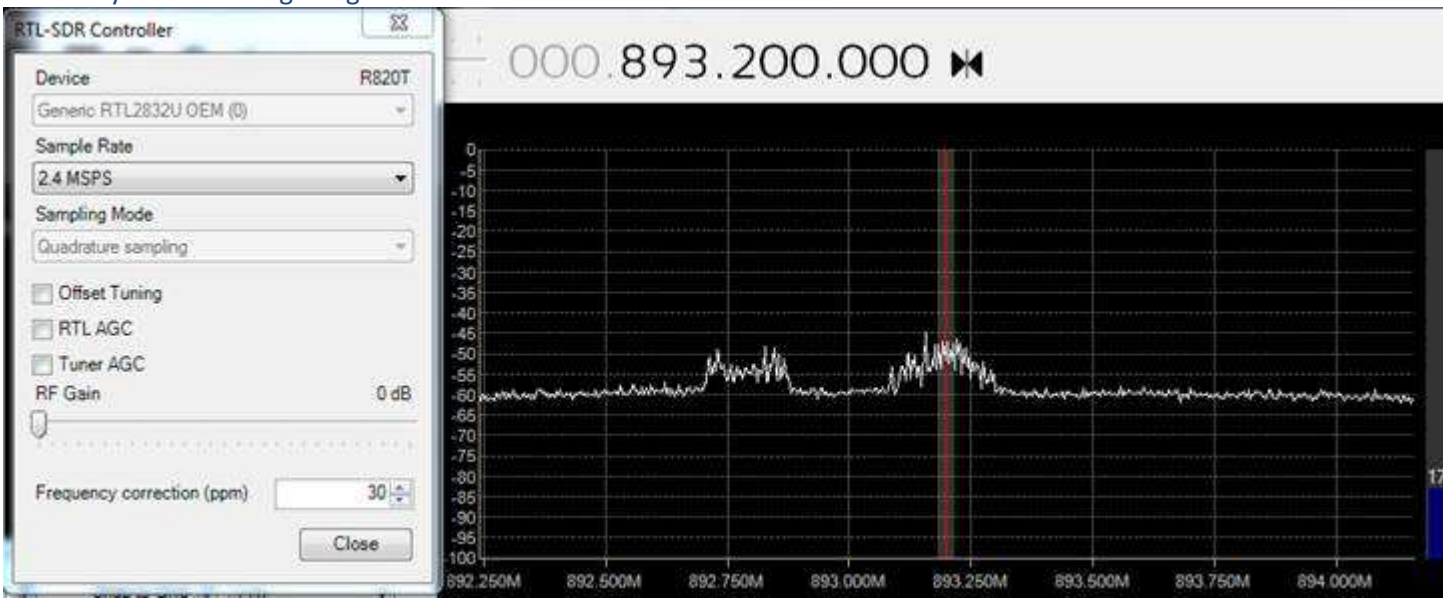


Gain 48 dB. Pig tail removed from the SDR. All received signal is coupled in to SDR and amplified by the LNA.

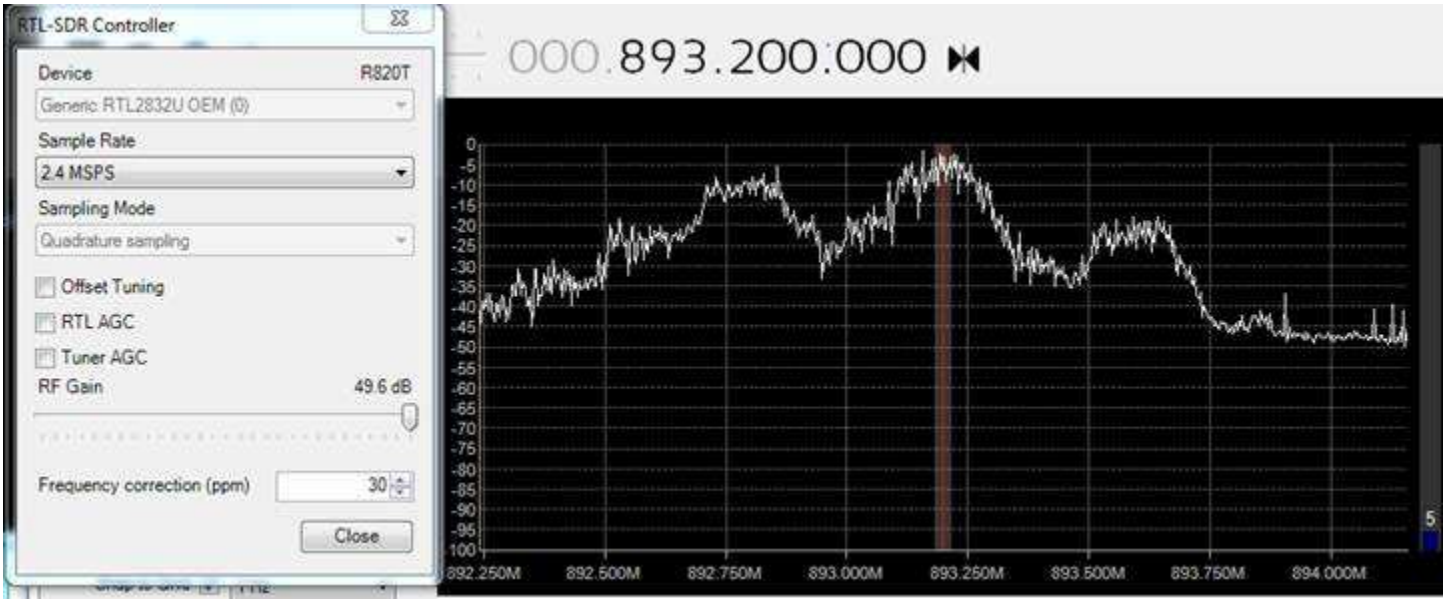


Note:

SDR# only allows setting the gain from 0 dB:



To 49.6 dB:


RTL-SDR Controller
Device
R820T
Generic RTL2832U OEM (0)
Sample Rate
2.4 MSPS
Sampling Mode
Quadrature sampling
Offset Tuning
RTL AGC
Tuner AGC
RF Gain
49.6 dB
Frequency correction (ppm)
30
Close
000.893.200:000
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
-95
-100
892.250M
892.500M
892.750M
893.000M
893.250M
893.500M
893.750M
894.000M

Gain measurements using kalibrate:
Using kalibrate, -1 dB is appears be minimum gain, 0 dB appears to be AGC enabled, and 49.6 dB is maximum gain. Also note the change in the “channel detect threshold” at each setting.

```
root@raspberrypi:/stratux# kal -v -d 0 -g -1 -s GSM850
Found 1 device(s):
  0:  Generic RTL2832U OEM

Using device 0: Generic RTL2832U OEM
Found Rafael Micro R820T tuner
Exact sample rate is: 270833.002142 Hz
[R82XX] PLL not locked!
Setting gain: -1.0 dB
kal: Scanning for GSM-850 base stations.
channel detect threshold: 24502.637734
GSM-850:
        chan: 248 (893.2MHz - 37.098kHz)        power: 29255.77
root@raspberrypi:/stratux# kal -v -d 0 -g 0 -s GSM850
Found 1 device(s):
  0:  Generic RTL2832U OEM

Using device 0: Generic RTL2832U OEM
Found Rafael Micro R820T tuner
Exact sample rate is: 270833.002142 Hz
[R82XX] PLL not locked!
kal: Scanning for GSM-850 base stations.
channel detect threshold: 39190.954479
GSM-850:
        chan: 151 (873.8MHz + 6.693kHz) power: 78836.78
        chan: 231 (889.8MHz - 37.367kHz)        power: 40040.07
        chan: 246 (892.8MHz - 38.167kHz)        power: 307061.84
        chan: 248 (893.2MHz - 38.068kHz)        power: 346263.35
        chan: 250 (893.6MHz - 37.025kHz)        power: 75486.58
root@raspberrypi:/stratux# kal -v -d 0 -g 49.6 -s GSM850
Found 1 device(s):
  0:  Generic RTL2832U OEM

Using device 0: Generic RTL2832U OEM
Found Rafael Micro R820T tuner
Exact sample rate is: 270833.002142 Hz
[R82XX] PLL not locked!
Setting gain: 49.6 dB
kal: Scanning for GSM-850 base stations.
channel detect threshold: 307018.126667
GSM-850:
        chan: 231 (889.8MHz - 37.043kHz)        power: 341677.82
        chan: 246 (892.8MHz - 37.838kHz)        power: 2687356.63
        chan: 247 (893.0MHz + 36.455kHz)        power: 1710824.27
```

chan: 248 (893.2MHz - 37.745kHz) power: 3701857.70

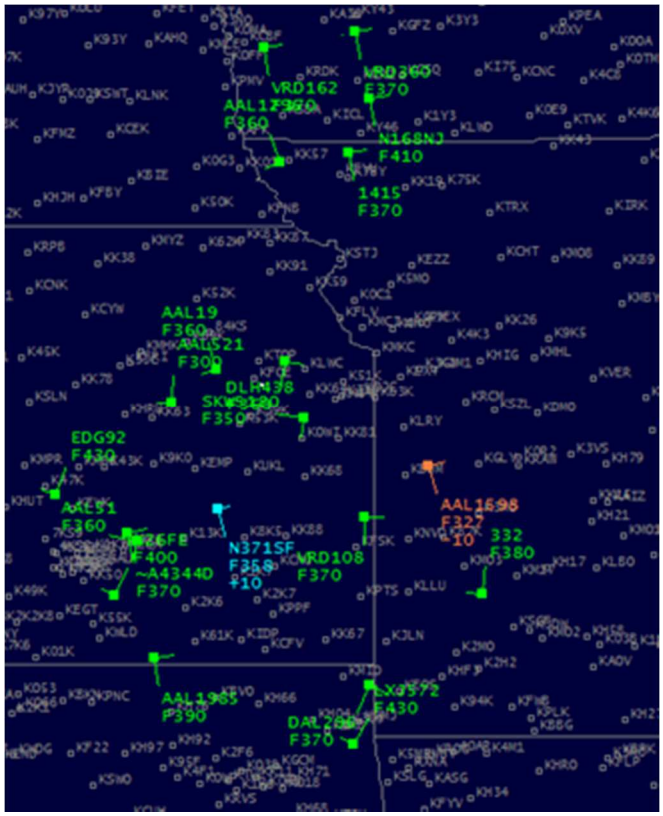
Testing gain with RTL1090:
Test Conditions:
Two Nano 2 dongles fed by the same antenna through a splitter. A phase variable line was utilized to tune the system to minimize the interaction between and maximize the signal to each dongle.

One dongle was connected to a PC running RTL1090 and the second dongle was installed in Stratux. Both dongles were turned to 1090 MHz. RTL1090 was used to tune and monitor the performance of the PC dongle while the Web UI and an EFB App was used to monitor Stratux.

Test Case #1:
RTL1090 was configured with the AGC active for both the IF amp and the LNA. The results are below.

This is the screenshot of the user's interface. The AGC is activated fit both amplifiers. This screenshot shows the receiver threshold is -83 dB. It also allows there are 77 aircraft being received including both Mode A/C and Mode S.

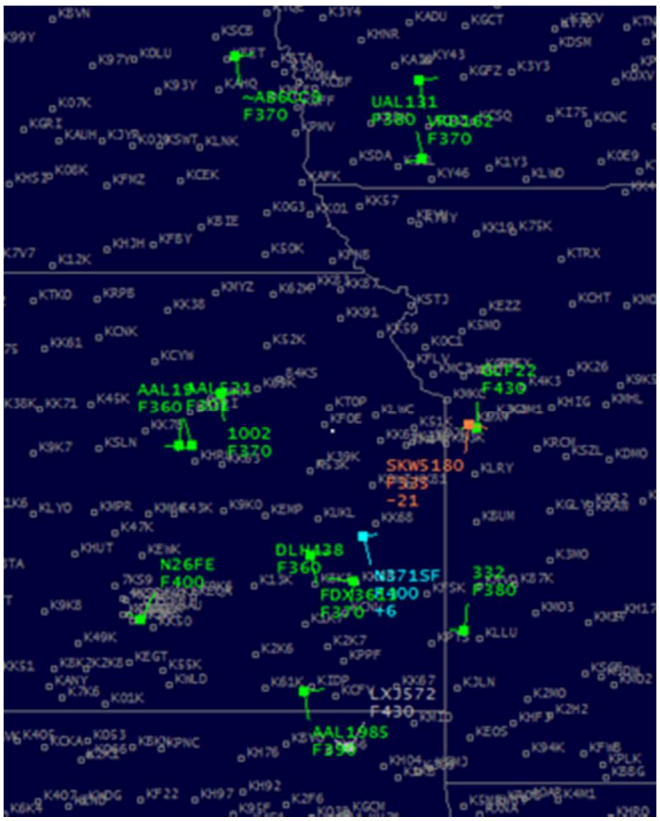
This is a screenshot of the RTL1090 map plot. It shows traffic from Southern Iowa through Northern Oklahoma. 20 unique Mode S targets are being tracked.



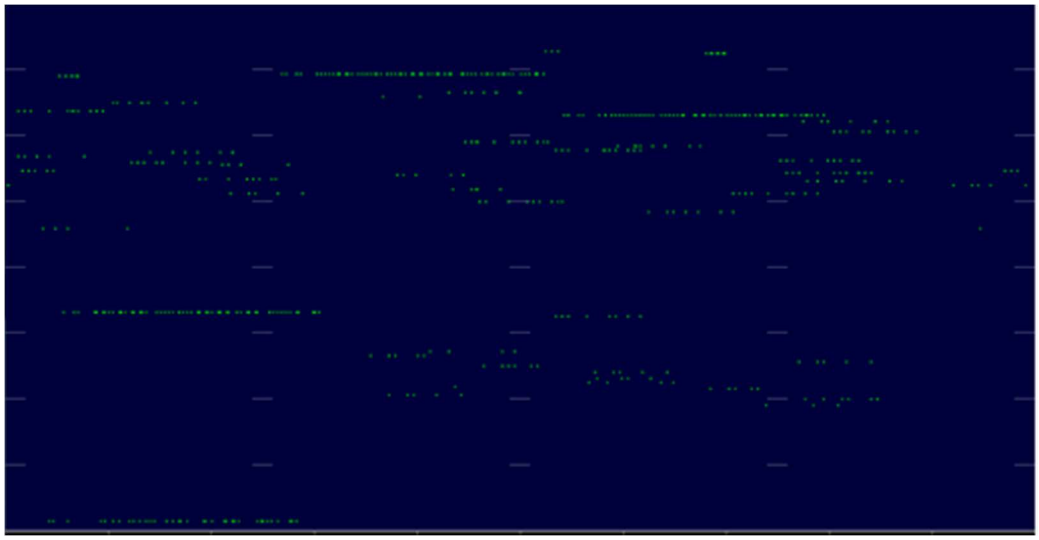
This is a signal plot from RTL1090. It provides a visual representation of the received signal. The long lines are Mode S signals. The shorter vertical in mic center through min bottom are Mode A/C signals. The shorter “dots” are noise bursts.

Test Case #2:
In this condition the Tuner AGC is set to 49.6 dB (Max) and the LNA AGC is enabled. The receiver threshold increased to -88 dB. The total number of aircraft tracked dropped to 49.

In this map plot 15 unique Mode S targets are being tracked.

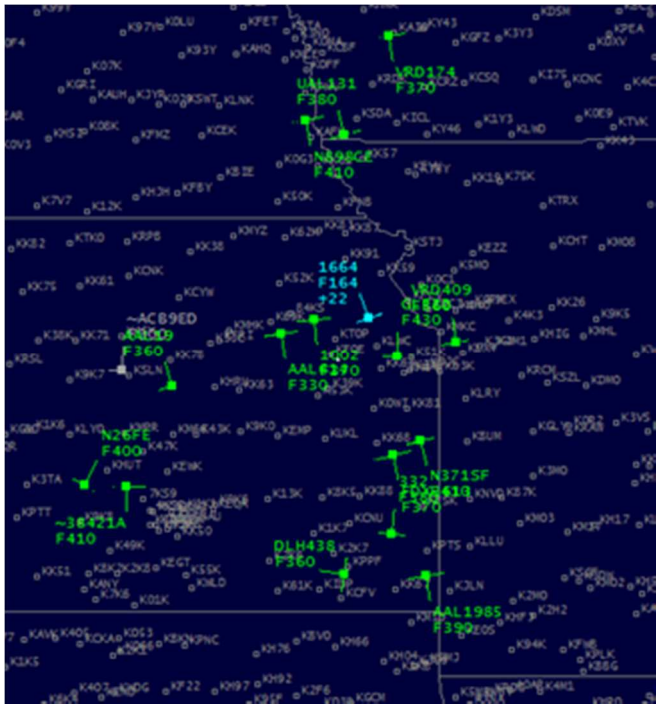


In this signal plot the number of received aircraft is down. Also, there is less noise presented to the detector.

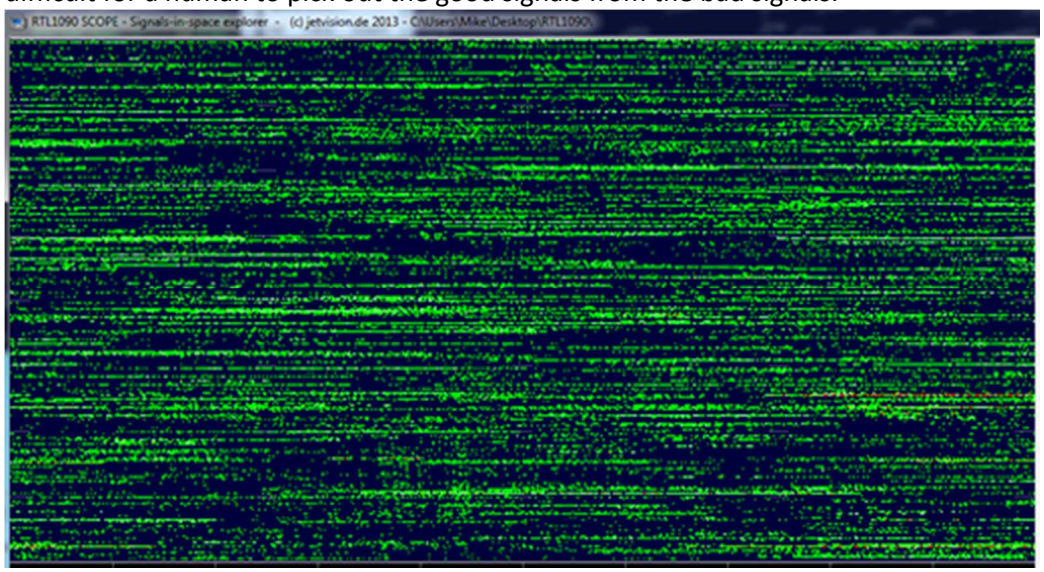


Test Case #3:
In this condition the Tuner AGC is set to 49.6 dB (Max) and the LNA AGC is disabled. I believe this sets the LNA gain to full. The receiver threshold increased to -77 dB enabled. The total number of aircraft being tracked increased to 67.

There are 17 unique Mode S aircraft in track.

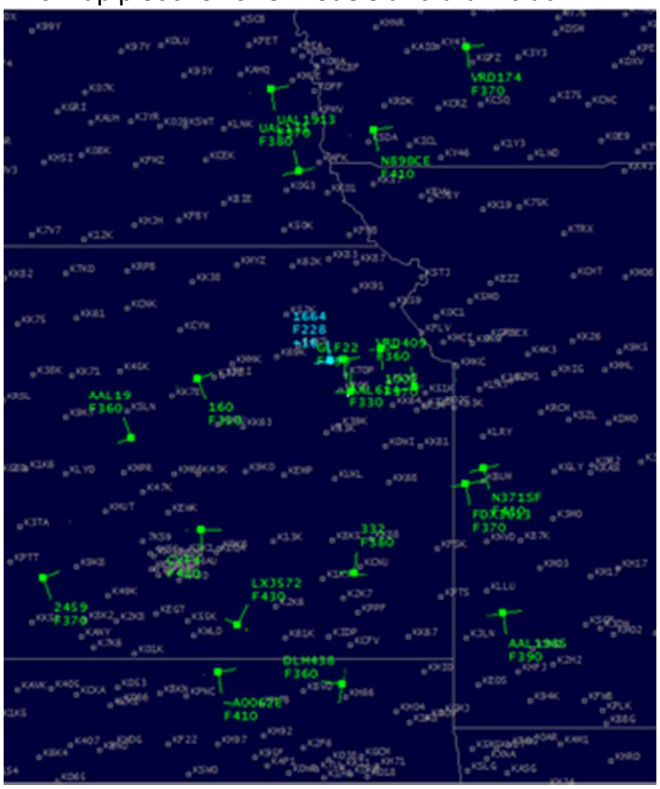


The signal plot shows an increase in the amount of noise that is presented to the detector. It is getting difficult for a human to pick out the good signals from the bad signals.

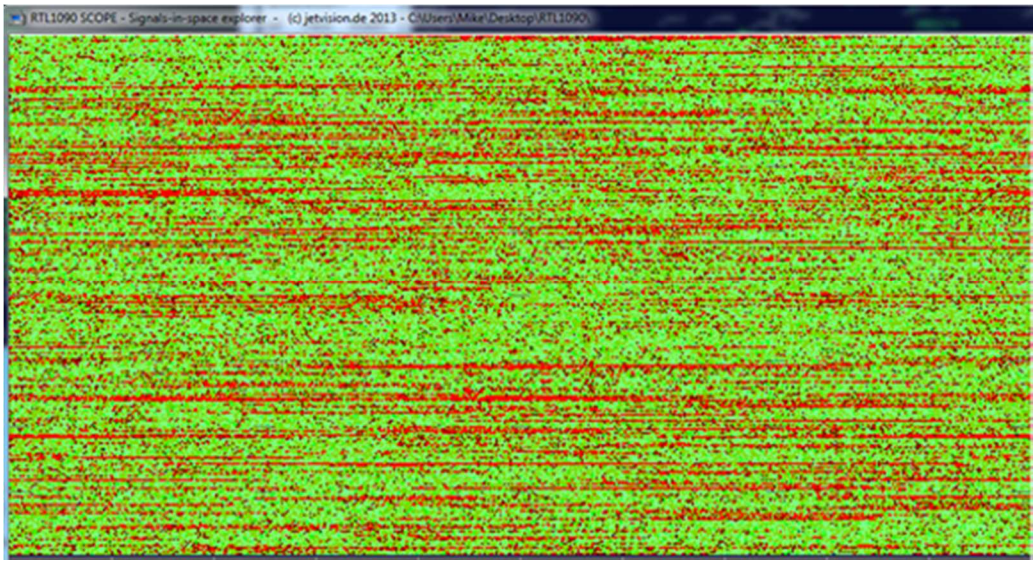


Test Case #4:
The Tuner AGC is enable and the LNA AGC is disabled. The receiver threshold increased to -72 dB. This a 11 dB decrease in receiver sensitivity over Test Case #1. Also at 70 it is tracking 7 few aircraft than Test Case #1.

This map plot shows 19 Mode S aircraft in track.



The signal plot shows excessive noise to the point that it is almost impossible for a human to see the aircraft signals.

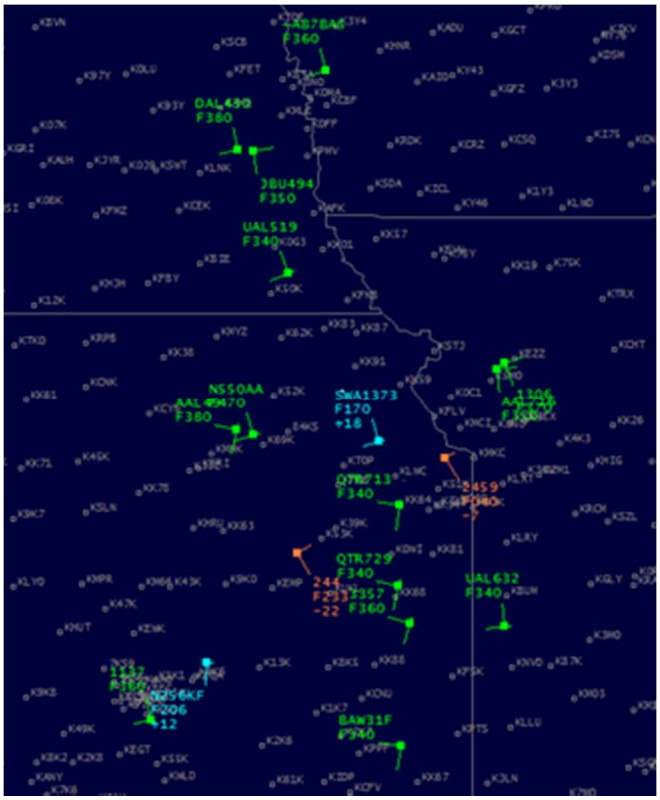


As stated earlier, Stratux was monitored in parallel with the RTL1090 data collection. Below is a screenshot of the Stratux Traffic page. At no point in the testing did the Stratux Nano 2 track as much 1090 traffic as the RTL1090 Nano 2 device.

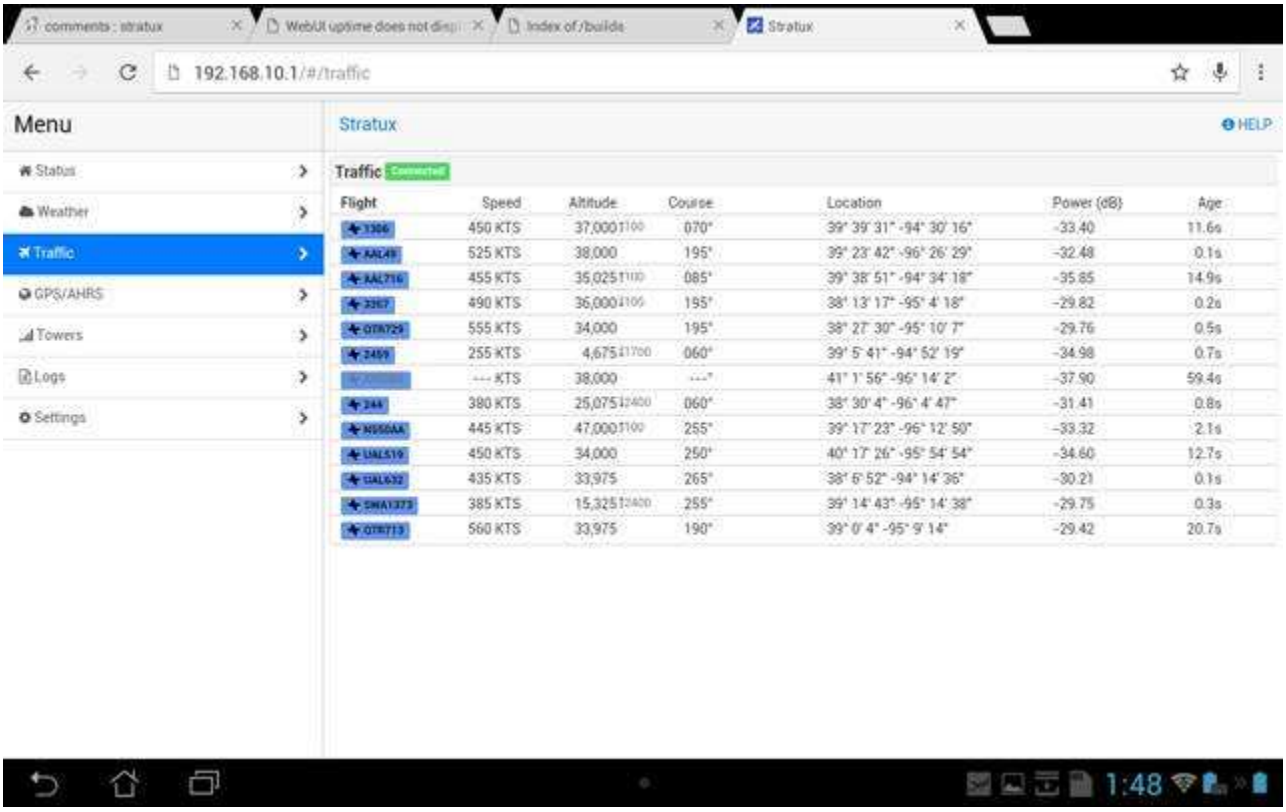
Traffic Connected

Flight	Speed	Altitude	Course	Location	Power (dB)	Age
[redacted]	--- KTS	35,000	---°	39° 3' 27" -96° 54' 33"	-35.17	40.5s
UAL131	440 KTS	38,000	255°	40° 30' 45" -96° 12' 0"	-37.45	6.7s
VRD409	425 KTS	36,025	260°	38° 58' 7" -95° 1' 14"	-33.42	45.8s
AAL614	450 KTS	33,000	080°	39° 12' 4" -95° 28' 0"	-33.55	0.4s
1664	435 KTS	24,725 ↑1900	260°	39° 8' 55" -95° 55' 39"	-34.75	0.2s
FDX3613	510 KTS	37,050 ↑100	080°	38° 18' 7" -94° 18' 30"	-34.17	0.7s
1002	475 KTS	37,000 ↓100	085°	39° 15' 57" -95° 5' 33"	-31.12	1.5s
GLF22	435 KTS	43,000 ↓100	270°	38° 56' 19" -95° 44' 42"	-28.90	1.1s
N371SF	410 KTS	41,000	075°	38° 24' 24" -94° 12' 4"	-34.05	2.0s

As a sanity check, data was collected a few hours later from each device. The Stratux Nano still tracks fewer targets than the RTL1090 Nano.


F360
DAL480
F380
JBU494
F350
UAL519
F340
NS50AA
F380
SWA1373
F170
+18
QTR729
F340
UAL632
F340
BAW31F
F340


Sectional
ADSB TRAFFIC DETECTED
048°
934 ft
1:39


comments : stratux
WebUI uptime does not disp
Index of /builds
Stratux
192.168.10.1/#/traffic
Menu
Status
Weather
Traffic
GPS/AHRS
Towers
Logs
Settings
Stratux
HELP
Traffic
Connected
Flight Speed Altitude Course Location Power (dB) Age
3306 450 KTS 37,000 ↑100 070° 39° 39' 31" -94° 30' 16" -33.40 11.6s
AAL49 525 KTS 38,000 195° 39° 23' 42" -96° 26' 29" -32.48 0.1s
AAL716 455 KTS 35,025 ↑100 085° 39° 38' 51" -94° 34' 18" -35.85 14.9s
3357 490 KTS 36,000 ↑100 195° 38° 13' 17" -95° 4' 18" -29.82 0.2s
GTA729 555 KTS 34,000 195° 38° 27' 30" -95° 10' 7" -29.76 0.5s
2459 255 KTS 4,675 ↑1700 060° 39° 5' 41" -94° 52' 19" -34.98 0.7s
--- KTS 38,000 ---° 41° 1' 56" -95° 14' 2" -37.90 59.4s
244 380 KTS 25,075 ↑400 060° 38° 30' 4" -96° 4' 47" -31.41 0.8s
N550AA 445 KTS 47,000 ↑100 255° 39° 17' 23" -96° 12' 50" -33.32 2.1s
UAL519 450 KTS 34,000 250° 40° 17' 26" -95° 54' 54" -34.60 12.7s
UAL632 435 KTS 33,975 265° 38° 6' 52" -94° 14' 36" -30.21 0.1s
SWA1373 385 KTS 15,325 ↑400 255° 39° 14' 43" -95° 14' 38" -29.75 0.3s
GTR713 560 KTS 33,975 190° 39° 0' 4" -95° 9' 14" -29.42 20.7s
1:48