

# Spring news in the GNSS and SDR domain

Michele Bavaro

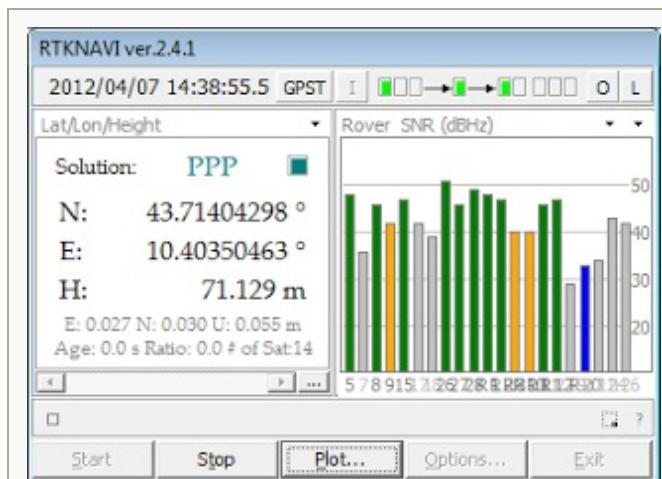
I have been following in the last few days interesting developments in the GNSS and SDR domain.

## 1. NV08C-CSM and dual constellation RAW measurements

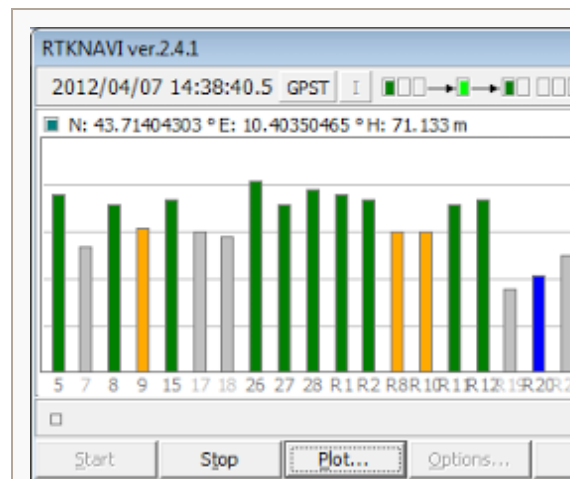
It's [recent news](#) that NVS has lifted the constraints on the firmware with RAW data for GPS and Glonass on L1. In my opinion this is one of those rare times that the rules of the game are changed by one of its players.

Essentially the NV08C-CSM provides real-time kinematic capability at 10Hz, with a price point as low as 35EUR/piece in small quantities. It is already possible to download an unofficial version of RTKNav.exe and RTKConv.exe [here](#), but [RTKLIB](#) will [officially support the receiver from next version](#) anyway.

Below are some pics of what Denga10 and the navXperience 3G+C could do with the good old 2.4.1 "Static Precise Point Positioning" over three hours.. bringing down the error to less than 20cm in complete standalone mode (by using only broadcast products).



Rtknavi (NVS mod) doing static PPP with 14 sats



Rtknavi (NVS mod) available satellite close-up

The screenshot shows the RTKNAVI ver.2.4.1: RTK Monitor interface. The top status bar displays the date and time: 2012/04/07 13:45:15. The main window shows a table of Glonass broadcast navigation data. The table has columns for SAT, PRN, Status, EOD, Freq, Heal, Age, Toe, Tof, X (m), Y (m), Z (m), VX (m/s), VY (m/s), VZ (m/s), AX (m/s^2), AY (m/s^2), and AZ (m/s^2). The data is for 14 satellites, with PRNs ranging from 1 to 14. The status is OK for all satellites. The coordinates are: X (m): 16513187.01, Y (m): -2163173.83, Z (m): 19325918.95. The velocities are: VX (m/s): 2409.32751, VY (m/s): 1096.32097, VZ (m/s): -1933.77686. The accelerations are: AX (m/s^2): 0.0000047, AY (m/s^2): -0.0000019, AZ (m/s^2): 0.0000000.

SAT	PRN	Status	EOD	Freq	Heal	Age	Toe	Tof	X (m)	Y (m)	Z (m)	VX (m/s)	VY (m/s)	VZ (m/s)	AX (m/s <sup>2</sup> )	AY (m/s <sup>2</sup> )	AZ (m/s <sup>2</sup> )
R1	1	OK	3	1	0	0	2012/04/07 13:45:15	2012/04/07 13:45:15	16513187.01	-2163173.83	19325918.95	2409.32751	1096.32097	-1933.77686	0.0000047	-0.0000019	0.0000000
R2	2	OK	3	-4	0	0	2012/04/07 13:45:15	2012/04/07 13:45:15	-676449.71	-12353916.50	22303230.47	2726.24397	1375.04578	845.69740	0.0000028	0.0000000	-0.0000000
R7	7	OK	1	5	0	0	2012/04/07 13:45:15	2012/04/07 13:45:15	18388830.55	16233064.94	-6963637.21	-706.13861	-668.15096	-3408.11539	0.0000019	-0.0000028	0.0000000
R8	8	OK	3	6	0	0	2012/04/07 13:45:15	2012/04/07 13:45:15	23417400.88	8923910.16	4776185.55	646.81530	166.34750	-3480.20077	0.0000037	-0.0000037	0.0000000
R11	11	OK	3	0	0	0	2012/04/07 13:45:15	2012/04/07 13:45:15	17878646.00	-2140938.48	18022168.95	-2127.62260	1271.00468	2269.15741	0.0000047	-0.0000019	0.0000000
R12	12	OK	3	-1	0	0	2012/04/07 13:45:15	2012/04/07 13:45:15	21801909.67	-13309128.91	1570984.86	-295.42542	-53.28274	3564.96048	0.0000056	-0.0000009	0.0000000
R19	19	OK	3	3	0	0	2012/04/07 13:45:15	2012/04/07 13:45:15	-9154069.34	11600706.05	20796997.56	-69.20147	-2847.34821	1558.23898	-0.0000009	0.0000000	-0.0000000

Glonass broadcast navigation data

RTKNAVI ver.2.4.1: RTK Monitor

Nav GPS/GAL Only OK Current

SAT	PRN	Status	CODE	CODE	Accu	Heal	Toc	Toc	Titrans	A (m)	e	0 (deg)	OMEGA0 (deg)	omega (deg)	MO (deg)	deltan (deg/s)	CM
2	2	OK	29	29	0	00	2012/04/07 14:00:00	2012/04/07 14:00:00	2012/04/07 13:35:38	26560379.878	0.01110629	53.80451	-14.15652	-161.46111	22.37019	2.9091E-07	-4.
5	5	OK	41	41	0	00	2012/04/07 14:00:00	2012/04/07 14:00:00	2012/04/07 13:35:38	26560044.051	0.00269148	54.52493	-46.72900	15.81752	136.21244	2.7032E-07	-4.
7	7	OK	30	30	0	00	2012/04/07 14:00:00	2012/04/07 14:00:00	2012/04/07 13:35:38	26559794.237	0.00520448	55.92062	167.67354	-173.19999	-60.18890	2.2146E-07	-4.
8	8	OK	169	169	0	00	2012/04/07 14:00:00	2012/04/07 14:00:00	2012/04/07 13:35:38	26560582.923	0.01215901	57.19040	172.38321	-170.43892	-97.26513	1.9048E-07	-4.
10	10	OK	96	96	0	00	2012/04/07 14:00:00	2012/04/07 14:00:00	2012/04/07 13:35:38	26560545.295	0.01124391	54.23104	47.98080	42.89975	155.65347	2.7470E-07	-4.
13	13	OK	6	6	0	00	2012/04/07 13:59:44	2012/04/07 13:59:44	2012/04/07 13:35:38	26560486.178	0.00493899	56.48990	112.04308	112.11469	73.43117	2.5287E-07	-4.
15	15	OK	96	96	0	00	2012/04/07 14:00:00	2012/04/07 14:00:00	2012/04/07 13:35:38	26561559.611	0.00439613	54.18238	105.59205	4.08999	50.09323	3.0833E-07	-5.
26	26	OK	83	83	0	00	2012/04/07 14:00:00	2012/04/07 14:00:00	2012/04/07 13:35:38	26560169.401	0.02097396	56.34937	111.70632	67.85060	20.58977	2.5999E-07	-5.
27	27	OK	12	12	0	00	2012/04/07 13:59:44	2012/04/07 13:59:44	2012/04/07 13:35:38	26561217.840	0.02175919	56.27633	164.64703	-63.03540	73.25179	2.1718E-07	-4.
28	28	OK	10	10	0	00	2012/04/07 13:59:44	2012/04/07 13:59:44	2012/04/07 13:35:38	26560704.224	0.01787044	56.05726	-130.42532	-104.84557	132.50792	2.2391E-07	-4.

GPS broadcast navigation data

RTKNAVI ver.2.4.1: RTK Monitor

Obs Data

Trcv	SAT	RCV	P1 (m)	P2 (m)	PS (m)	L1 (cycle)	L2 (cycle)	L5 (cycle)	D1 (Hz)	D2 (Hz)	D5 (Hz)	S1 (dB)	S2 (dB)	S5 (dB)	L1L1	L1L2
2012/04/07 14:38:06.500	5	1	22044584.894	0.000	0.000	905179.937	0.000	0.000	-2495.057	0.000	0.000	48.0	0.0	0.0	0	0
2012/04/07 14:38:06.500	7	1	25042546.391	0.000	0.000	19872436.785	0.000	0.000	-2828.859	0.000	0.000	38.0	0.0	0.0	0	0
2012/04/07 14:38:06.500	8	1	21934293.889	0.000	0.000	4727398.221	0.000	0.000	-1999.194	0.000	0.000	47.0	0.0	0.0	0	0
2012/04/07 14:38:06.500	9	1	24496604.389	0.000	0.000	-3653176.042	0.000	0.000	3637.915	0.000	0.000	41.0	0.0	0.0	0	0
2012/04/07 14:38:06.500	15	1	22404710.213	0.000	0.000	-15694744.062	0.000	0.000	3041.680	0.000	0.000	47.0	0.0	0.0	0	0
2012/04/07 14:38:06.500	17	1	24845045.012	0.000	0.000	-1765897.386	0.000	0.000	3168.863	0.000	0.000	39.0	0.0	0.0	0	0
2012/04/07 14:38:06.500	18	1	25438433.058	0.000	0.000	-259663.998	0.000	0.000	3389.365	0.000	0.000	40.0	0.0	0.0	0	0
2012/04/07 14:38:06.500	26	1	19880208.743	0.000	0.000	-18955623.976	0.000	0.000	554.132	0.000	0.000	51.0	0.0	0.0	0	0
2012/04/07 14:38:06.500	27	1	22447548.873	0.000	0.000	-13380432.997	0.000	0.000	2310.241	0.000	0.000	47.0	0.0	0.0	0	0
2012/04/07 14:38:06.500	28	1	20985078.775	0.000	0.000	-19133296.200	0.000	0.000	146.320	0.000	0.000	48.0	0.0	0.0	0	0
2012/04/07 14:38:06.500	R1	1	19630273.284	0.000	0.000	-14414096.696	0.000	0.000	-1523.865	0.000	0.000	48.0	0.0	0.0	0	0
2012/04/07 14:38:06.500	R2	1	20841853.849	0.000	0.000	-19465925.639	0.000	0.000	2878.311	0.000	0.000	46.0	0.0	0.0	0	0
2012/04/07 14:38:06.500	R8	1	22805780.402	0.000	0.000	17043276.332	0.000	0.000	-4166.980	0.000	0.000	40.0	0.0	0.0	0	0
2012/04/07 14:38:06.500	R10	1	22885120.162	0.000	0.000	17511552.359	0.000	0.000	-3179.017	0.000	0.000	40.0	0.0	0.0	0	0
2012/04/07 14:38:06.500	R11	1	19608926.702	0.000	0.000	-11329055.435	0.000	0.000	-1100.900	0.000	0.000	46.0	0.0	0.0	0	0
2012/04/07 14:38:06.500	R12	1	20779393.786	0.000	0.000	-20152142.041	0.000	0.000	2500.713	0.000	0.000	47.0	0.0	0.0	0	0
2012/04/07 14:38:06.500	R19	1	24134779.881	0.000	0.000	-1593179.433	0.000	0.000	-1317.478	0.000	0.000	27.0	0.0	0.0	0	0
2012/04/07 14:38:06.500	R20	1	23109483.125	0.000	0.000	-5940725.805	0.000	0.000	1816.929	0.000	0.000	33.0	0.0	0.0	0	0
2012/04/07 14:38:06.500	R21	1	24072818.550	0.000	0.000	-643487.130	0.000	0.000	3855.844	0.000	0.000	35.0	0.0	0.0	0	0
2012/04/07 14:38:06.500	124	1	37125798.223	0.000	0.000	-2201340.582	0.000	0.000	555.860	0.000	0.000	43.0	0.0	0.0	0	0
2012/04/07 14:38:06.500	126	1	37703669.417	0.000	0.000	-2344610.446	0.000	0.000	256.942	0.000	0.000	42.0	0.0	0.0	0	0

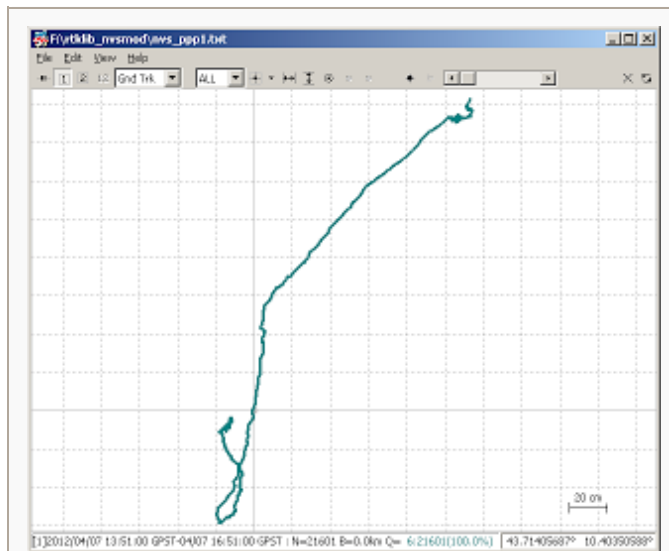
GPS/Glonass observations.. 21!

RTKNAVI ver.2.4.1: RTK Monitor

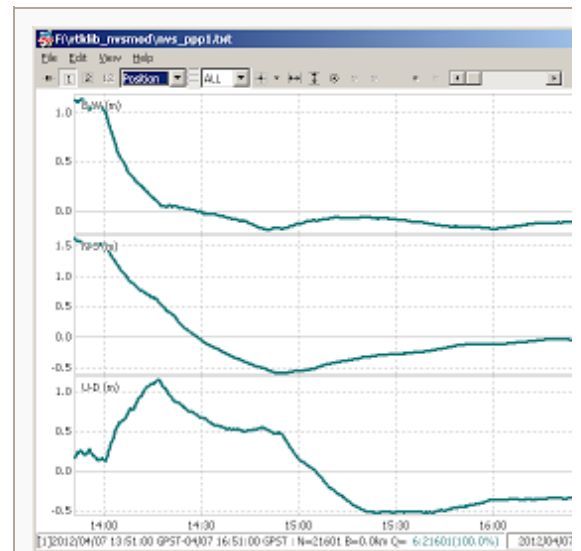
Satellites Only OK

SAT	PRN	Status	Azimuth	Elevation	L1	L2	L5	Fix1	Fix2	Fix5	P1 Resid	P2 Resid	PS Resid	L1 Resid	L2 Resid	L5 Resid	Slip1	Slip2	Slip5	Lock1	Lock2	Lock5	Outage1	Outage2
5	5	OK	203.5	40.1	OK	-	-	-	-	-	-0.93	0.00	0.00	-0.1498	0.0000	0.0000	0	0	0	7664	0	0	0	0
8	8	OK	36.3	38.9	OK	-	-	-	-	-	-0.45	0.00	0.00	0.1284	0.0000	0.0000	0	0	0	7664	0	0	0	0
9	9	OK	258.6	10.7	OK	-	-	-	-	-	-0.61	0.00	0.00	-0.3031	0.0000	0.0000	0	0	0	258	0	0	0	0
15	15	OK	304.5	34.6	OK	-	-	-	-	-	-1.32	0.00	0.00	-0.4606	0.0000	0.0000	0	0	0	7664	0	0	0	0
26	26	OK	351.1	79.5	OK	-	-	-	-	-	0.09	0.00	0.00	-0.3499	0.0000	0.0000	0	0	0	7664	0	0	0	0
27	27	OK	266.0	33.1	OK	-	-	-	-	-	5.97	0.00	0.00	0.4839	0.0000	0.0000	0	0	0	7664	0	0	0	0
28	28	OK	96.8	64.7	OK	-	-	-	-	-	-1.26	0.00	0.00	-0.0489	0.0000	0.0000	0	0	0	7664	0	0	0	0
R1	1	OK	209.0	63.1	OK	-	-	-	-	-	0.49	0.00	0.00	-0.4911	0.0000	0.0000	0	0	0	7657	0	0	0	0
R2	2	OK	316.8	42.6	OK	-	-	-	-	-	-2.55	0.00	0.00	-1.3121	0.0000	0.0000	0	0	0	7657	0	0	0	0
R8	8	OK	169.1	16.6	OK	-	-	-	-	-	-7.17	0.00	0.00	-1.8391	0.0000	0.0000	0	0	0	7656	0	0	0	0
R10	10	OK	50.2	16.0	OK	-	-	-	-	-	10.36	0.00	0.00	-0.3370	0.0000	0.0000	0	0	0	4706	0	0	0	0
R11	11	OK	11.4	62.8	OK	-	-	-	-	-	3.99	0.00	0.00	0.2854	0.0000	0.0000	0	0	0	7657	0	0	0	0
R12	12	OK	260.9	43.4	OK	-	-	-	-	-	-1.26	0.00	0.00	0.1335	0.0000	0.0000	0	0	0	7657	0	0	0	0
R20	20	OK	99.0	14.8	OK	-	-	-	-	-	-1.03	0.00	0.00	-0.2855	0.0000	0.0000	0	0	0	2661	0	0	0	0

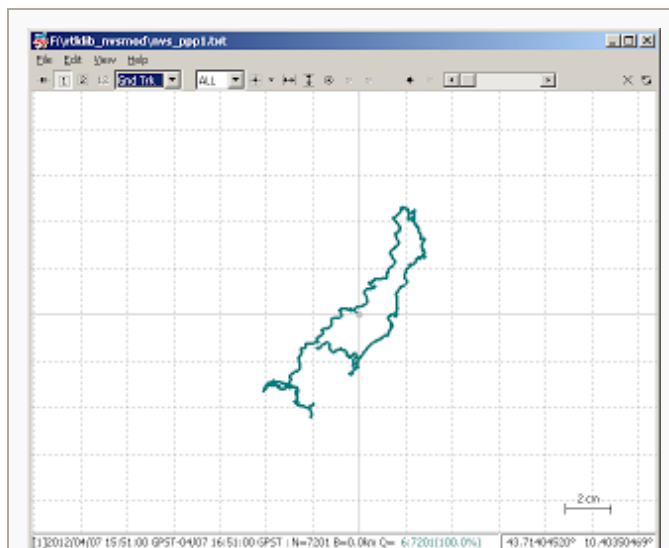
Satellites used in the fix



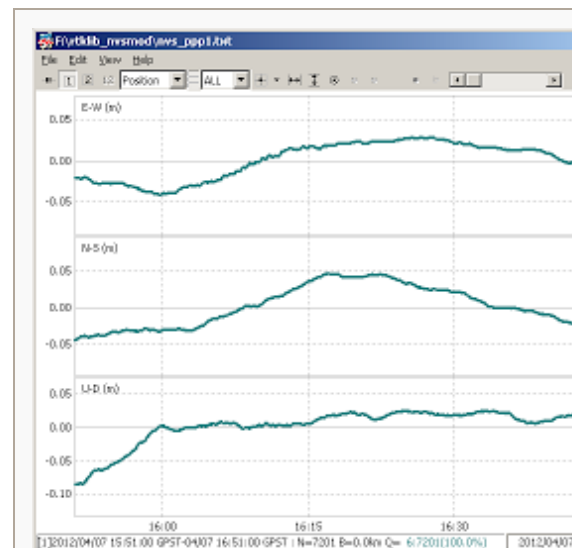
From cold start, first three hours, ground track



From cold start, first three hours, position



From cold start, third hour, ground track



From cold start, third hour, position

The likes of Novatel, Trimble, Hemisphere, etc are not going to like it I suppose. On the other hand, users have perhaps a cheaper option to enter the high-precision domain.

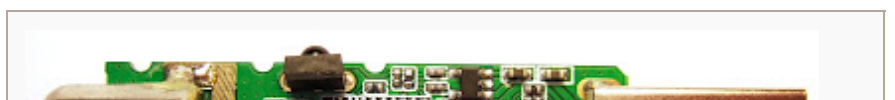
## 2. RTL-SDR

For once, the group of innovators is European.

These guys of [osmocom](#) are **smart** and -what's even better- their work with the open source team. [RTL-SDR](#) is, I believe, one of the freshest finds in the Software Defined Radio domain. The [Fun Cube Dongle](#), developed in UK, is already a very clever tool. But finding the super-tuner [Elonics E4000](#) (note, again a UK Company) in [25\\$ USB DVB-T dongles](#) and being able to grab data in a 3MHz bandwidth between 64MHz and 1.7GHz... that is really cool.

I had to buy one! ...actually two before I found the E4000..

The Realtek RTL2832U demodulator uses a 28.8MHz

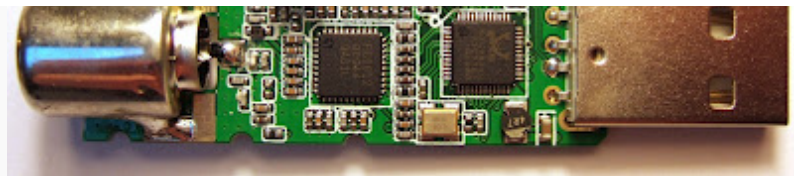
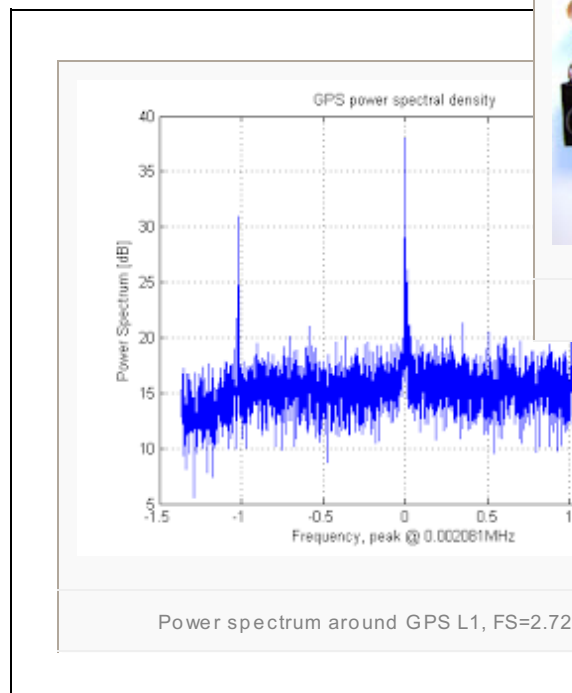




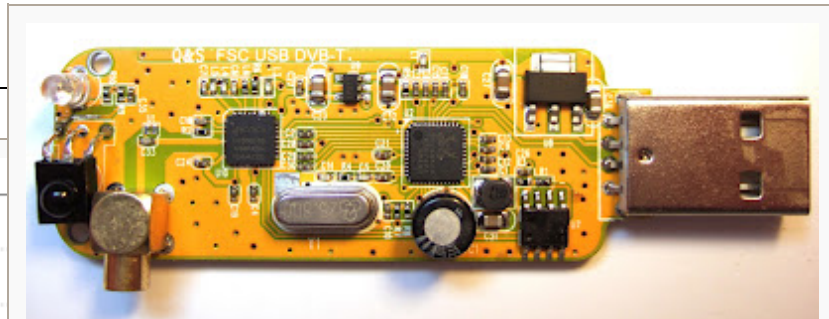
crystal by default.. which has too poor accuracy for a GPS receiver.. but a SDR acquisition algorithm can easily handle 100+kHz of apparent Doppler shift in the frequency search :)

So for a nominal sky plot as the one below:

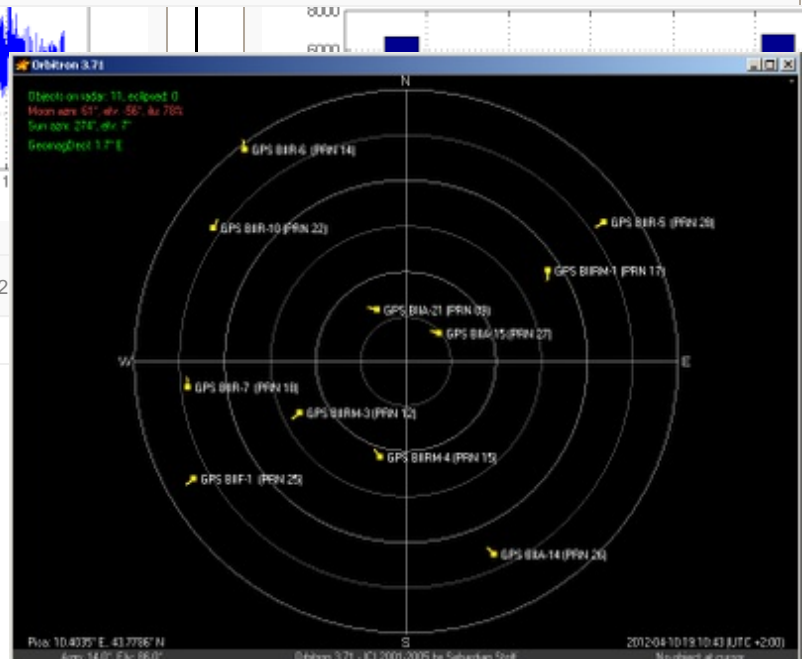
And a signal looking like as follows:



A Terratec Cinergy T Stick Black rev.1, with the FC0012 which is not suitable for GPS



A Newsky TV28T, with the E4000.

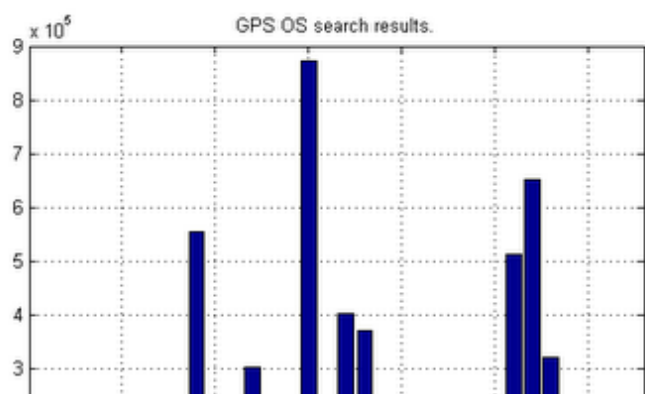


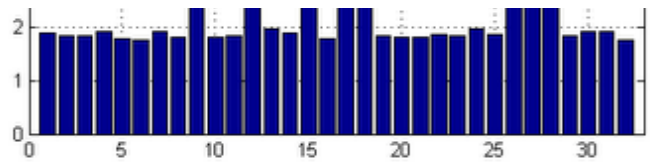
I could acquire the following birds:

SV 9: Doppler +112000.0 CodeShift: 99 xcorr: 553566.6  
 SV12: Doppler +113500.0 CodeShift: 502 xcorr: 301126.3  
 SV15: Doppler +110000.0 CodeShift: 1847 xcorr: 871305.9  
 SV17: Doppler +110500.0 CodeShift: 2225 xcorr: 401100.6  
 SV18: Doppler +110000.0 CodeShift: 38 xcorr: 368766.1  
 SV26: Doppler +107000.0 CodeShift: 1779 xcorr: 511844.4  
 SV27: Doppler +110500.0 CodeShift: 264 xcorr: 650033.9  
 SV28: Doppler +107500.0 CodeShift: 203 xcorr: 320405.6

The next step is to have my new version of GPS-SDR processing the data in real-time.. won't be long!

I managed to upload the binary file which is long enough for everyone with a SDR receiver to calculate the position. I used FS=2.048MHz and a nominal IF of 0.0Hz (but because of the crystal inaccuracy the IF actually falls at about 110kHz). The data type is I&Q interleaved int8\_t.





[https://rapidshare.com/files/558977948/20120415\\_1714BST\\_fs2048\\_iq8.001.dat](https://rapidshare.com/files/558977948/20120415_1714BST_fs2048_iq8.001.dat)

[https://rapidshare.com/files/2431212520/20120415\\_1714BST\\_fs2048\\_iq8.002.dat](https://rapidshare.com/files/2431212520/20120415_1714BST_fs2048_iq8.002.dat)

[https://rapidshare.com/files/4187716662/20120415\\_1714BST\\_fs2048\\_iq8.003.dat](https://rapidshare.com/files/4187716662/20120415_1714BST_fs2048_iq8.003.dat)

[https://rapidshare.com/files/107864226/20120415\\_1714BST\\_fs2048\\_iq8.004.dat](https://rapidshare.com/files/107864226/20120415_1714BST_fs2048_iq8.004.dat)

### 3. Open source FPGA receivers

I waited too long for the code from the University of Tampere: they were promising to licence the [TUTGNSS](#) and never happened.

Finally the Open Source community is bringing to the reality an Open Source FPGA implementation of a GPS receiver based on the [Namuru](#) / [Zarlink GP2021](#) correlator structure and soft CPU cores (the [LatticeMico32 Milkymist](#) and the Altera [NiosIIe](#)). As also scientists at the University of Tokio (remember RTKLIB?) are involved, this time I know it is going to happen.

Some useful links:

<http://gnss-sdr.ru/index.php?blogid=2>

[http://en.qi-hardware.com/wiki/GPS\\_Free\\_Stack](http://en.qi-hardware.com/wiki/GPS_Free_Stack)

<http://blog.goo.ne.jp/osqzss/>

Stay tuned, GNSS is evolving rapidly!