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A new WSPR transmitter for Balloons

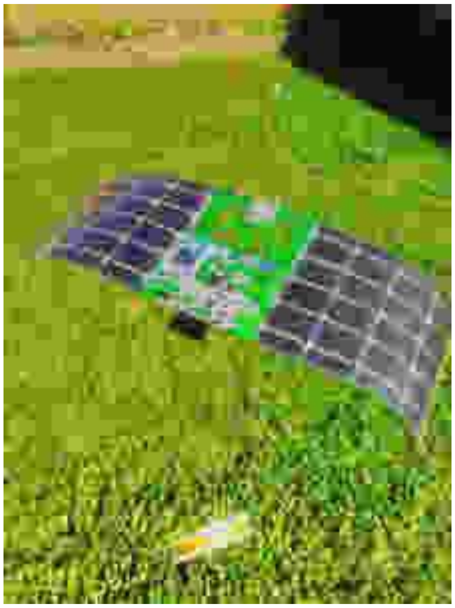
8-10 minutes

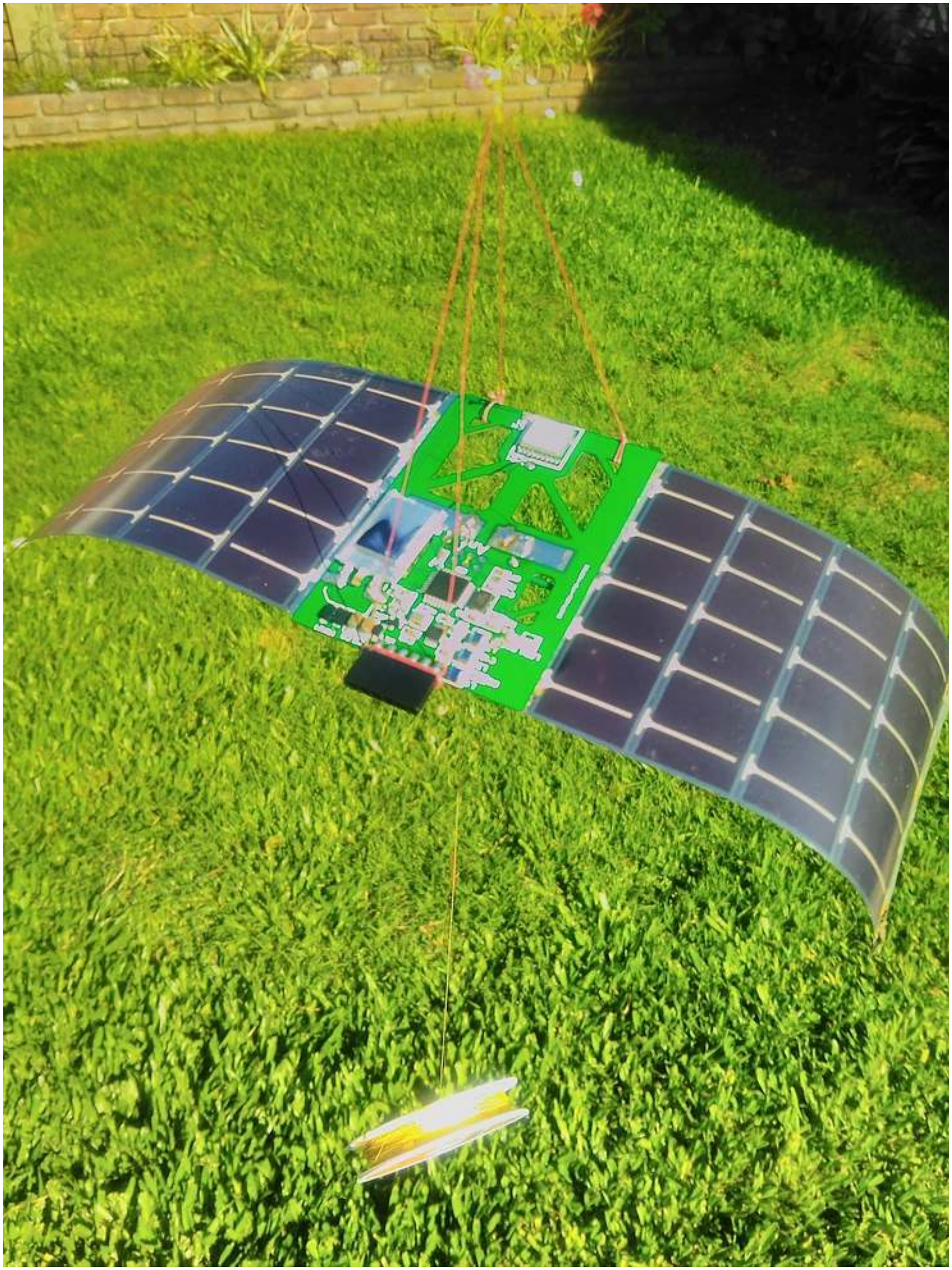
After a long development time I have now released my latest WSPR transmitter that is intended to be flown with small balloons. There is a big world wide community that flies very light transmitters with small helium or hydrogen filled balloons. These type of balloons are typically called Pico balloons as they only carry a payload of 15grams or lighter, hence the new transmitter is called WSPR-TX Pico.

It started about 9 month ago when I was contacted by a couple of hams that had seen my WSPR-Mini and had thought of flying it. In the subsequent email communication back and fort with them discussing the specifics of balloon flight with small party balloons I decided to start to design a custom board for this applications in co-operation with LU1ESY - Ignacio.

Ignacio is an experienced balloon flyer and he also have a big network of Amateurs that launches balloons and other autonomous vehicles from Argentina.

A picture of the transmitter in it's harness. This was board revision one and here the solar cells are soldered along the sides and four strings is holding the board level.



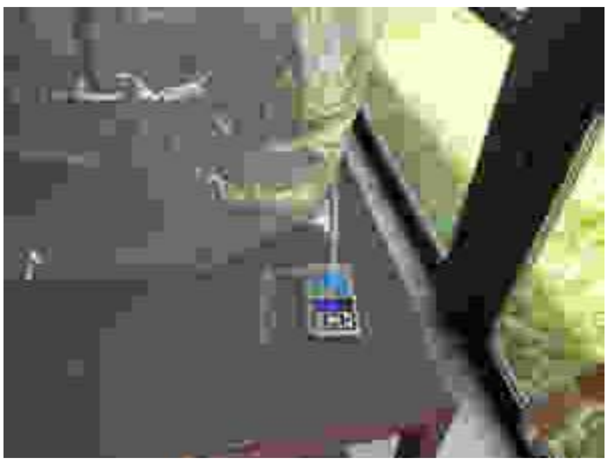


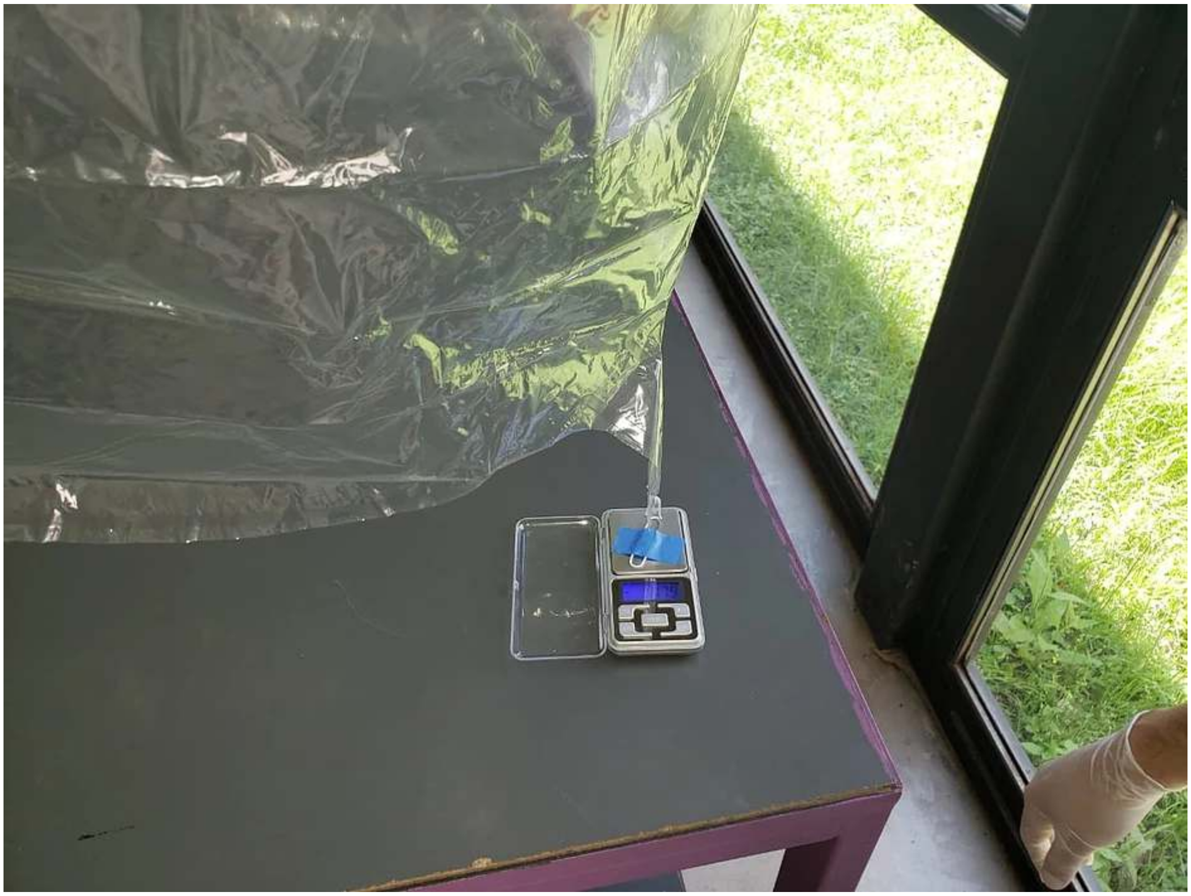
As the development was progressing we had a couple of flights with different prototypes, the first one was flown by Tucuman RC launch group (about 1250 km northwest of Buenos Aires) in Argentina in November 2019.

The jolly group of amateurs in Tucuman.

Filling preparations.

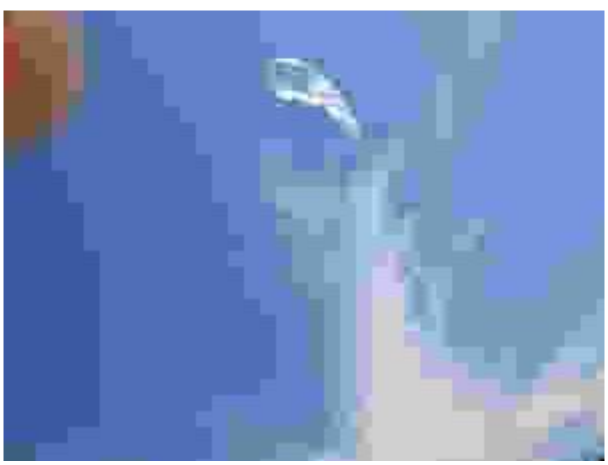
Measuring the lift.





Launch!

Up, up up....



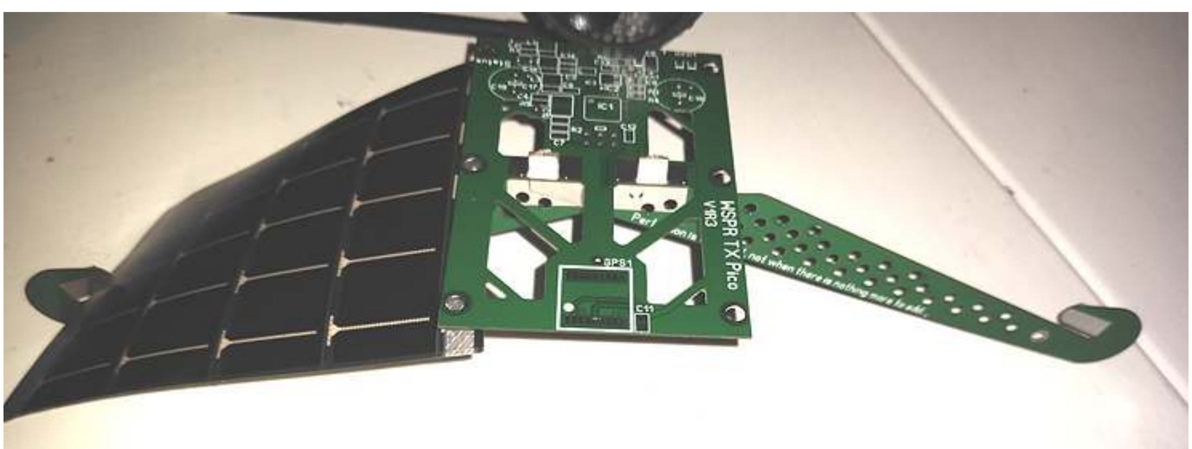
It was launched on a hot day and it climbed straight up for several hours, as every report showed it being in the same grid I first suspected that maybe it was miss-configured to use a fixed grid but finally it showed up in a new grid, it had more or less gone straight up to about 10km altitude. Altitude was encoded in to the power field of the WSPR protocol. This made it possible for us to learn both were it was and on what altitude.

I later learned that the weather was very hot and calm with virtually no winds. This was a great first test and it operated during the day until the sun was to low. The next day it woke up and transmitted for a few hours, it has gained some altitude and everything looked fine when is suddenly went silent mid-day.

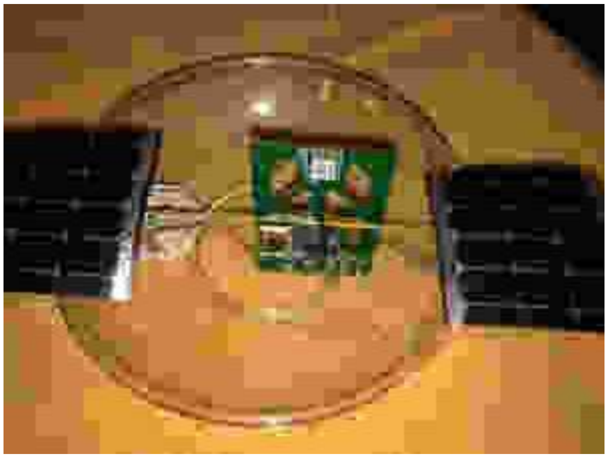
That is just the way it is with balloon flights I guess. It can die suddenly and you will never know what has happened, balloon burst? electronics failure? We will never know. But even if this first flight only lasted two days it proved that the electronics could survive during days and night in the cold of 10 to 11km altitude. It also showed that startup worked fine when the sun got up and that the Altitude reporting coding was working as intended so at least for me it was a successful flight even if I guess that the guys in Argentina had wished for a longer flight.

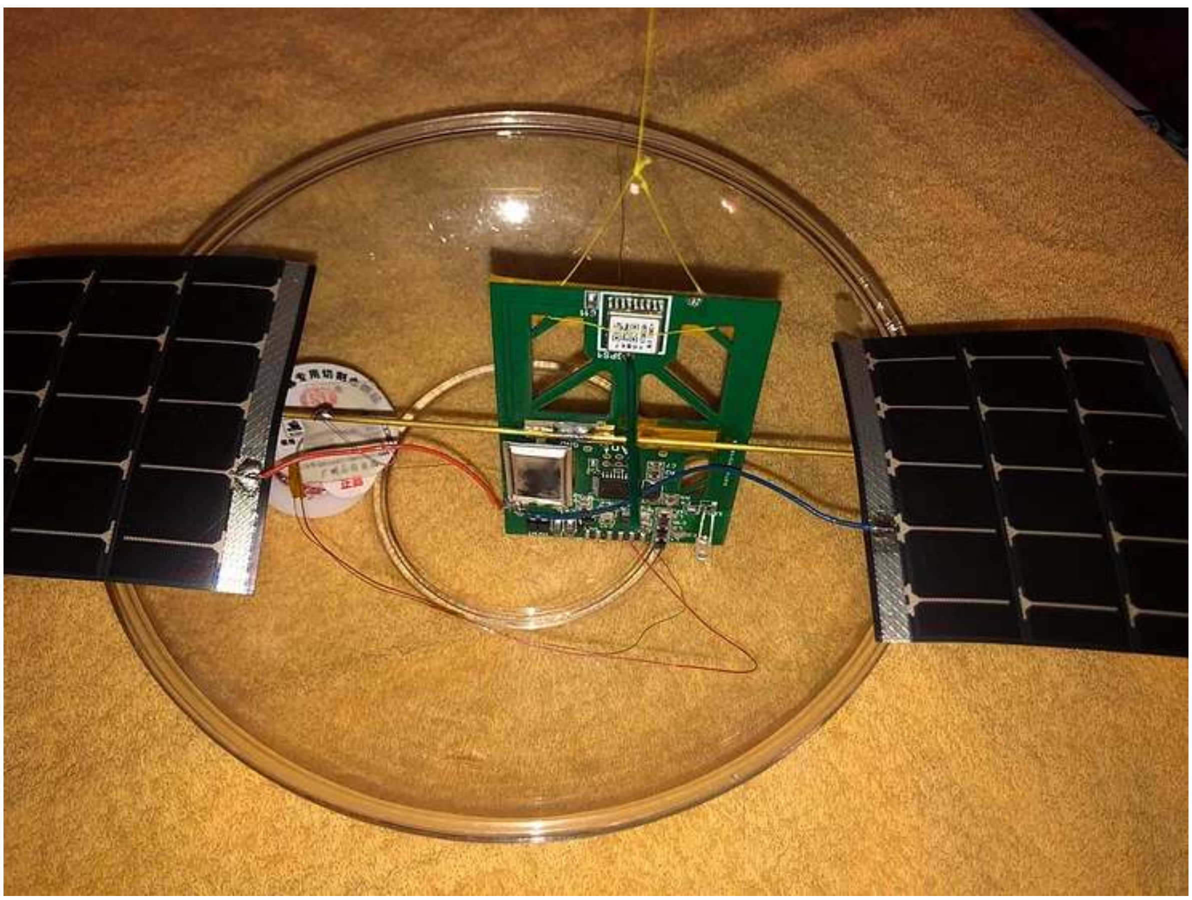
Development continued on the next revision and one problem I would like to solve was how to hold the solar cells out at a slight downward angle so it could operate at different solar angles. We used a piece of wire on the first prototype but I was not happy with that. To be fair I think I over designed the next revision. It had these nice arms made out of PCB material that was supposed to be soldered in to hold the solar cells.

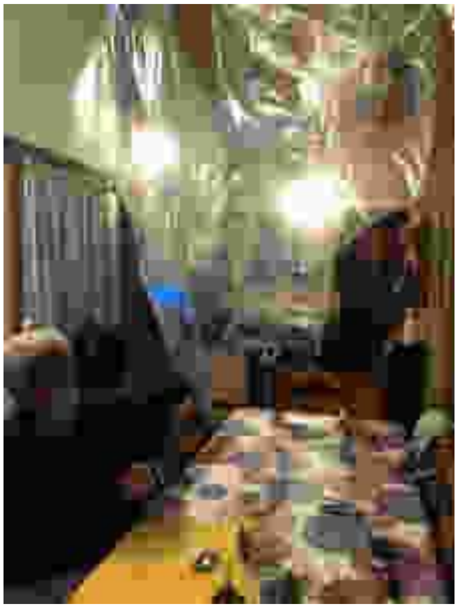
Se picture below to get an idea how it was supposed to work.



The next was with this revision 2 but without the arms as they was not ready when I sent the next prototype to Ignacio. He modified it and soldered a brass tube in the middle of the board to hold the solar cells as he wanted to have it hanging straight down from the harness and not try to keep the board level with four anchor points as in the first one.







This second flight was released at mid-day the 9th of January 2020 from the Villa Gisele beach in Argentina. The launch was a bit rough and Ignacio gave the following account of it. "A lot of wind caused a rugged launch. The tracker hit a tree and then another ...

and finally released and climbed." We were of course worried that that the bad launch had caused some damage to the solar cells or the antenna and during the first days only 30m reports were being received even though it transmitted on both 20m and 30m.

This was probably just due to propagation effects and it was actually working quite fine so our worry was unfounded.

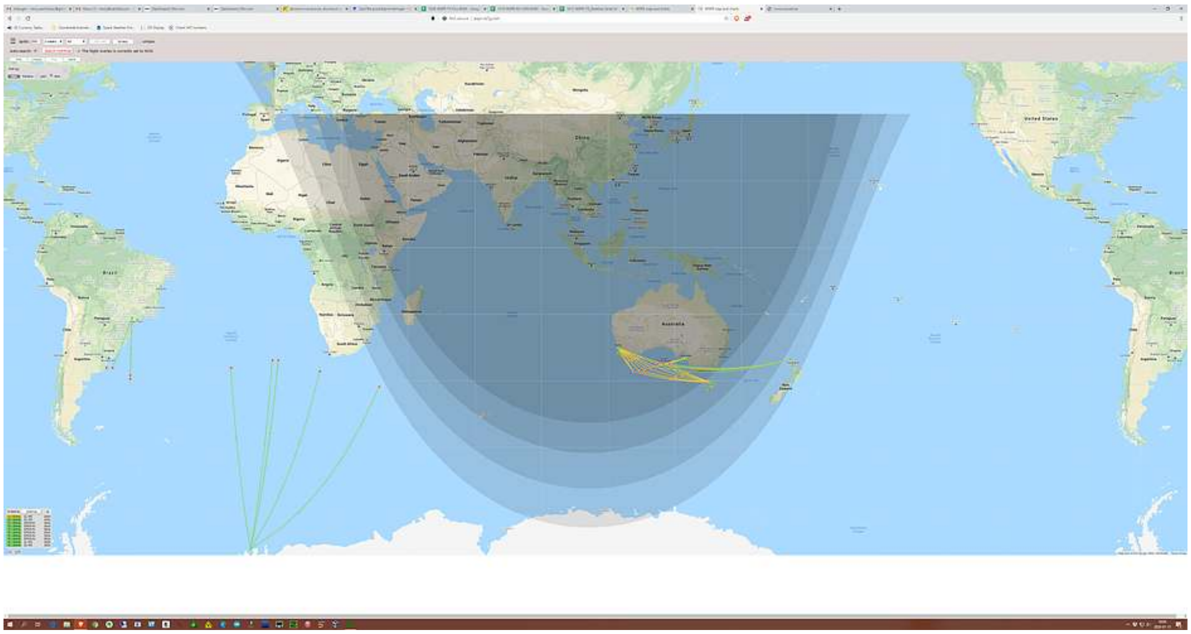
To make the best out of the dual band transmitter design Ignacio had made a clever contraption to get the antenna to be dual band so it could be equally effective on both the 30m and 20m bands.

The normal thing to do in this case would be to have two so called "traps" witch are parallel resonant LC circuits out on the each dipole leg. But to save weight he made only one trap and placed it on one leg and made this one extra long so the total lenght would be one half wave for 30m.

This works fine even if it is a bit unorthodox, the only difference is that on 30m the antenna gets to be fed off-center and the impedance will be around 100ohm according to Ignacio. The SWR on 30m would then be 2:1 but that is quite acceptable if the main goal is to have it as light weight as possible.

The balloon and the WSPR transmitter operated perfectly as it drifted east over the south Atlantic over the days first passing slightly south of South Africa and a finally ending up over Australia were it was picked up by lots of receiving stations in Australia and New Zealand.

The dual band operation proved to be a valuable feature as the first few days the only spots were from 30m from stations in Brazil and the Antarctic. Once it reached Australia both bands were picked up so if this would have been a 20m only balloon it would have been a very long wait for the first spots :-).



The speed dropped over Australia and it spent three days slowly drifting.

After two days it changed directions and started going south towards Tasmania. And on the third day over Australia hanging high in the sky over the smoke from the bush fires - it suddenly stopped working.

It had been traveling for more than a week and I was a sad it did not complete a full circumnavigation, maybe next time :-)

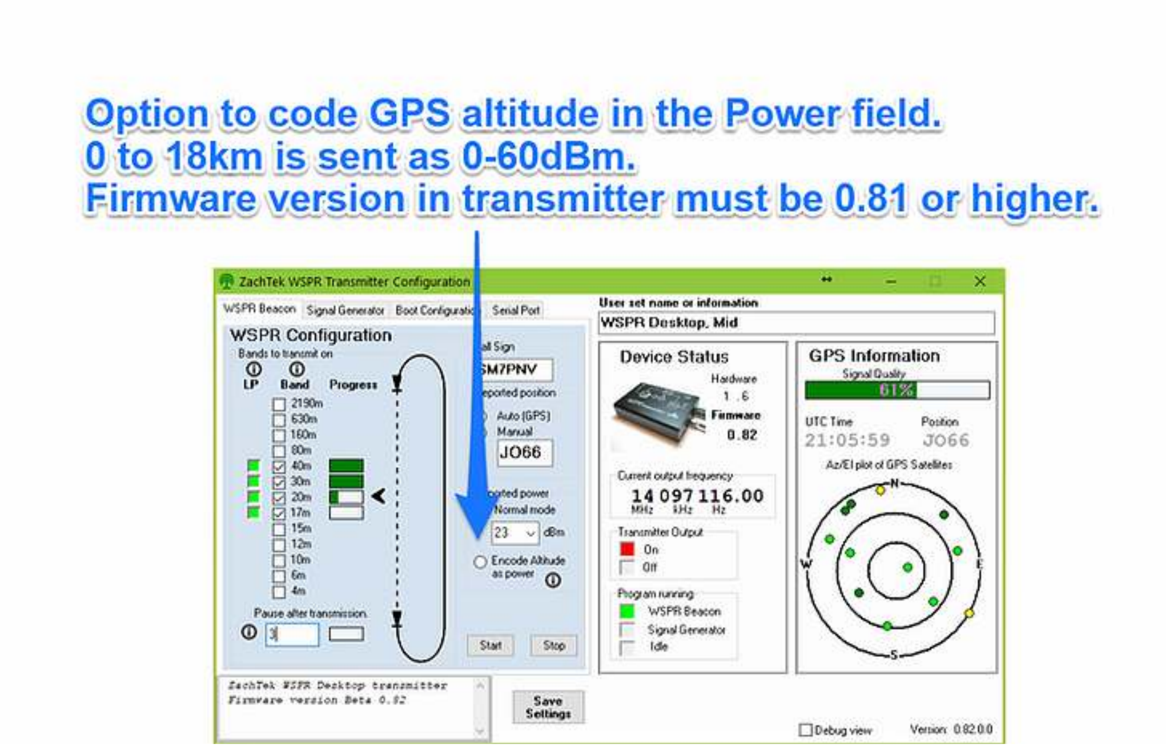
The last day of operation it transmitted for 10,5 hours so the solar cells worked fine at low angles it seems.

After this flight I created final iteration of the design. Now I focused even more on the weight.

I shrank the size of the board, I made it in the thinnest PCB material board only 0.4 mm thick and it is now designed to hang vertical and the solar cells are soldered in to a slot.

I also completed the software, while the previous designs had use a custom compiled firmware that implemented Altitude to Power coding scheme I now folded this code in to my standard firmware and implemented support for it in the PC configuration software. That means that all my WSPR transmitters can now use this Altitude option if needed.

It is as easy as just tick an option in the config software to get it.



The encoding is pretty simple, the WSPR protocol can report power output from 0 to 60 dBm in 3 dB steps I choose 18km as max altitude as most GPS stops working at this Altitude anyway and most Pico balloons don't go over 11km so this seemed like a good max limit. The calculation is then pretty easy - the Arduino will just divide the altitude with 300 to get the dBm value.

Here is a table that show the conversion between Altitude and power reporting value.

Power to Altitude in meter. Conversion table

Power dBm	Power Watt	Altitude Min	Altitude Max
0	1mW	0	900
3	2mW	900	2100
7	5mW	2100	3000
10	10mW	3000	3900
13	20mW	3900	5100
17	50mW	5100	6000
20	100mW	6000	6900
23	200mW	6900	8100
27	500mW	8100	9000
30	1	9000	9900
33	2	9900	11100
37	5	11100	12000
40	10	12000	12900
43	20	12900	14100
47	50	14100	15000
50	100	15000	15900
53	200	15900	17100
57	500	17100	18000
60	1kW	18000	

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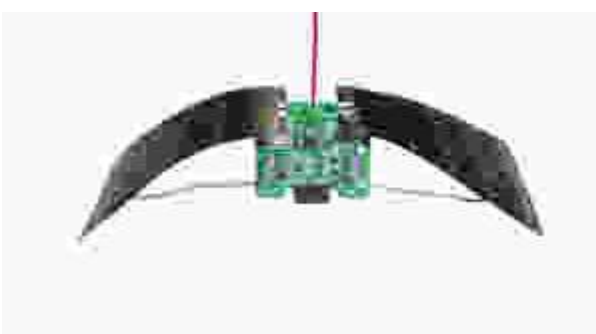
27	500mW	8100	9000
30	1	9000	9900
33	2	9900	11100
37	5	11100	12000
40	10	12000	12900
43	20	12900	14100
47	50	14100	15000
50	100	15000	15900
53	200	15900	17100
57	500	17100	18000
60	1kW	18000	

A photo of the final design that I now have in my shop.



The final version is also the lightest one of all the revisions and weighs just 10.5 grams with solar cells so I believe it is the lightest of the commercial WSPR balloon trackers .

I believe this can be great unit for many users that just want to fly something without doing to much assembly or construction. There are no software skills required to get it flight-ready as the configuration is done using a Windows software. They also comes calibrated to the nearest sub-hertz in output frequency so you can feel confident with it being on frequency. I also believe it is the lowest cost, the nearest competitor charge 100$ for a unit with without solar cells.

I now have a first batch in stock that I hope will find their way to lot of great balloon flights and travel the world at high altitude.

I sell them in my shop now for 90$ but the first 20 sold will have an introduction price of only 70$ Check out the Shop and documentation page for more information.

73

//Harry