# Some notes about flying Clear Chinese balloons with the U4B transmitter by VE3KCL

## Super Pressure Balloon

A weather balloon is filled with a lifting gas like hydrogen or helium and as it rises, the density and pressure of the air outside the balloon decreases and the balloon expands. Because the weather balloon is made of latex, and is elastic, the external pressure becomes less as the balloon rises. The internal pressure becomes relatively higher than the external pressure. The balloon keeps expanding as the outside pressure decreases till a point when the balloon cannot expand anymore and it bursts.

A super pressure balloon is different from a latex balloon, used by the weather service, in that it's walls are not that elastic. As a super pressure balloon rises and the external pressure decreases, because the walls of the balloon are much stronger, as the balloon fully inflates, the walls will resist expanding more and the balloon stops going up as the volume of the balloon does not increase any more. At this point the density of the balloon and its payload becomes stable, the balloon stops rising, its density is equal to the density of the outside air. This point of equilibrium is referred to as the float level. As the balloon volume is kept relatively constant the density of the balloon and its payload remains constant, and the balloon will float along at that level for long periods of time.

## Hydrogen storage

Hydrogen gas can be purchased from the welding supply as it has welding applications. Hydrogen is usually pure gas. Sometimes Party balloon Helium is mixed with air to fill more balloons for less money. This type of party balloon Helium is not suitable for use in Super pressure or floater balloons. It can cause the balloon to burst prematurely or not float as high, and instead, pure Helium is preferred. Hydrogen is flammable but has a few advantages over Helium. Hydrogen has more lift than helium, is a renewable resource, and it does not leak through a balloon membrane as quickly as Helium.

The Hydrogen from the welding supply comes in high pressure cylinders containing greater than 2000 psi pressure. I have used 20 lb. propane tanks to hold the Hydrogen at a lower pressure, just for filling balloons. The rated pressure of a propane tank is about 300 psi. These propane tanks are filled with about 150 psi of hydrogen that has been reduced through a gas regulator from the high-pressure hydrogen cylinder. The propane tank is fitted with a ball valve to control the outflow of hydrogen into the balloon and a pressure gauge that indicates the remaining pressure in the tank.  A three-foot clear plastic hose goes from the ball valve and is then reduced to a narrow tapered ¼" hose that will fit in the balloon neck, or fill port. The tank when filled to 150 psi. can properly inflate about four 36-inch balloons before it needs to be refilled again. The tank of Hydrogen should be stored outside the house, in a well-ventilated place.

*A convenient old tank with a ball valve, for filling balloons. The gauge indicates about 65 psi that will fill about 2 more balloons.*

## Pre-stretching Chinese Clear Balloons

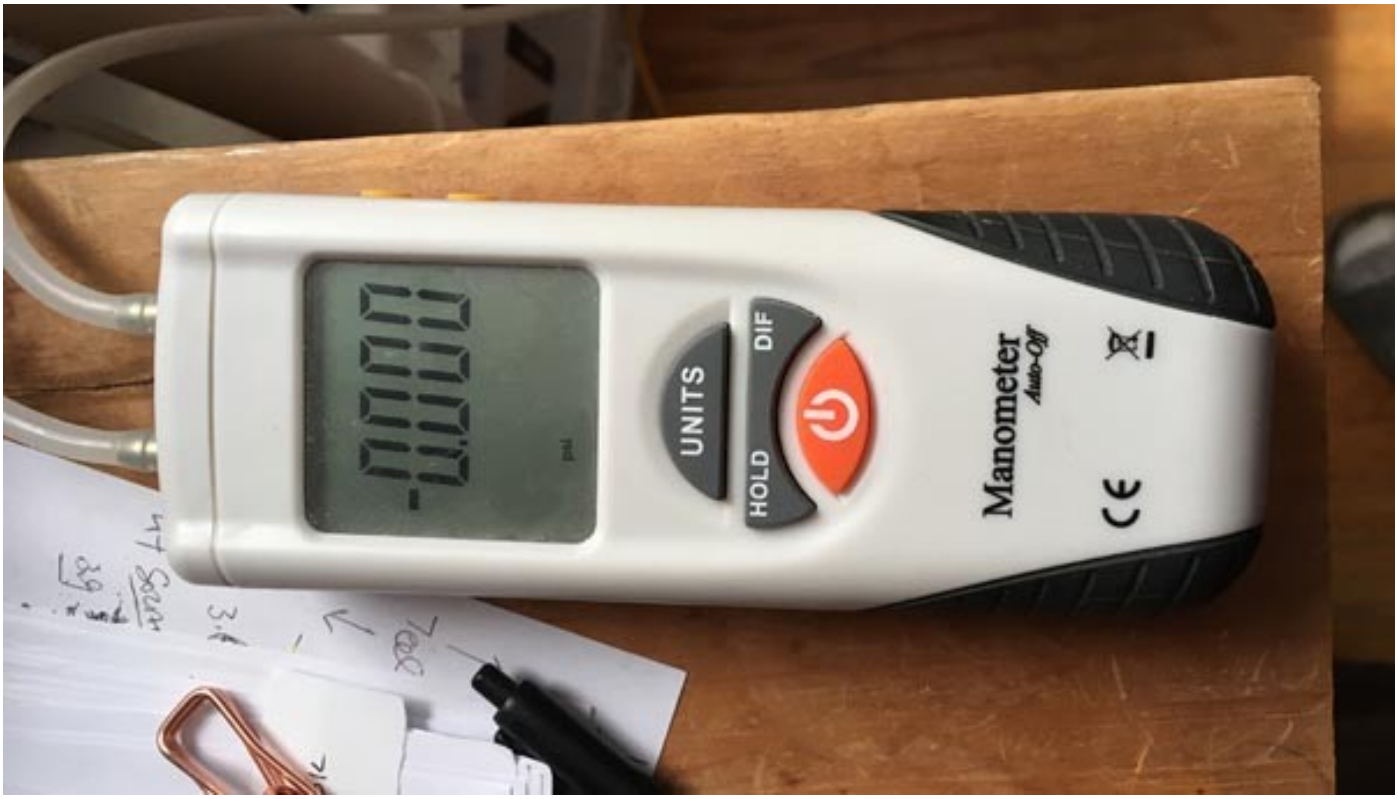
Not all varieties of balloons are suited to pre-stretching. The Clear 36-inch balloons from Aliexpress used in the last flights, can be stretched before flight. The burst pressure on these balloons varies but is in the range of .65psi. As too much handling is bad for the balloon envelope. These balloons are stored flat between 2 pieces of 3/16” plywood with a black plastic sheet taped next to the plywood.


*Flat balloon storage S.A.G. balloons on top then clear Chinese then Qualatex*

As soon as the balloon package arrives in the mail, the date of arrival is written on the neck of the balloons, and then they are transferred to the middle of this wooden sandwich. The edges of the plywood are fastened with spring clips.


*The questionable perimeter seals on the left side of the clear balloon above will be resealed with the band sealer.*

On occasion the perimeter seals of the balloon are sub optimal, and an impulse or band sealer is used to go over any sections of perimeter seal that do not look good.  A modified fish tank air pump for about $12 can provide air pressure to stretch balloons and even some vacuum to evacuate them. To make the pump work for vacuum, one seals the inlet holes for the intake manifold in the bottom of the air pump with silicone and a new hole is drilled into the intake manifold. Into this hole, a plastic pipe made from a from an aquarium hose joiner is glued in with crazy glue. To inflate and control the pressure while stretching the balloons, one uses a pressure regulator to limit the pressure and a manometer to measure the line pressure or inflation pressure in the balloon.




*A manometer to accurately measure the balloon's internal pressure*

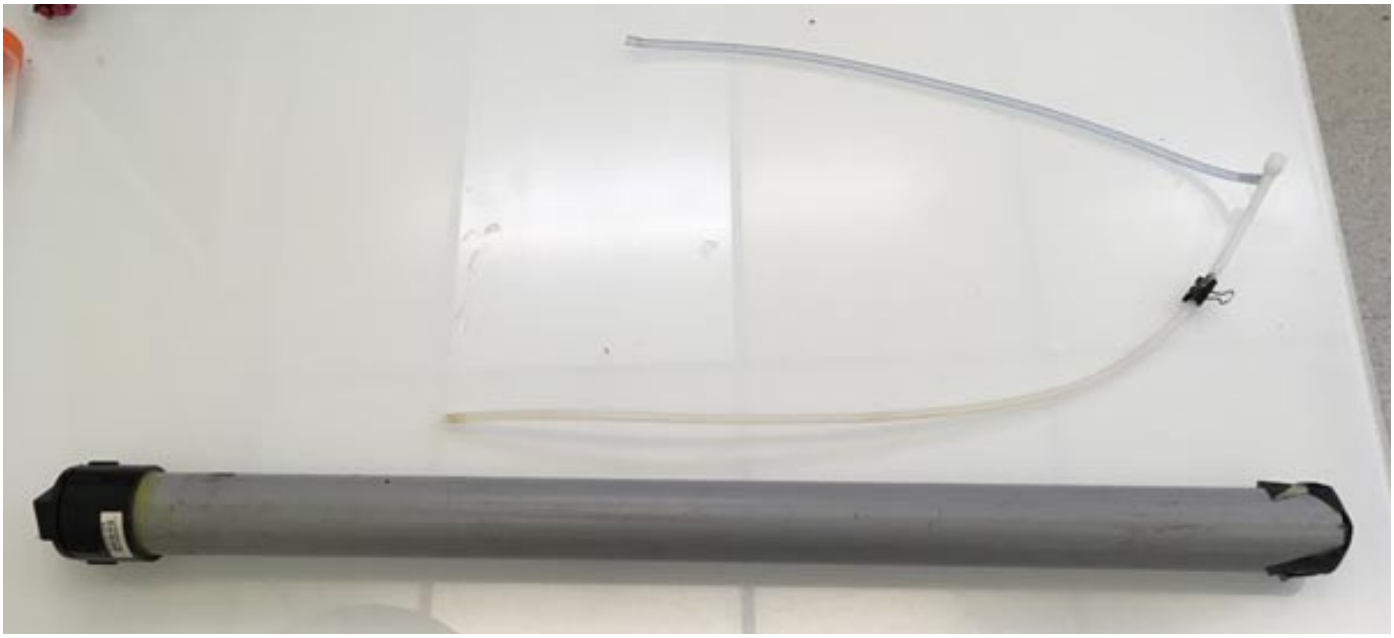
## The Pressure Regulator

I believe I may be the first person after Archimedes to reinvent this simple reliable pressure regulator.

It consists of a 28-inch-long piece of plastic pipe with a cap on one end so the end is watertight. The pipe is sanding in a bucket with a clip and rubber band keeping the pipe vertical. The grey pipe is filled with water up to approximately 6 inches from the top. The way it works is, the deeper you put the white air pressure hose into the pipe, the more pressure is required for the air to bubble up through the water. If you want higher pressure, you put the white air pressure hose deeper into the water. In my case I have some tape on the top of the pipe to reduce splashing and a spring clip to hold the white air pressure hose at a constant depth or pressure. The manometer in line with the pressure line will instantly read the pressure on the regulator ,while the water is bubbling up through the regulator. It is such a simple if not beautiful device.

The way it is connected … pressure side of the aquarium pump … tee fitting to manometer … tee fitting to pressure regulator and then aquarium line to the balloons you want to fill (usually with tee fittings) … To get an instant pressure reading on the regulator pressure, squeeze the plastic line to the balloons and then all the air will go through the regulator and the manometer will show the maximum regulated pressure.  While squeezing the balloon line you can move the white air pressure hose up and down in the grey pipe and read the manometer to get the pressure you desire. Once you have the pressure you want, use a spring clamp to hold the white air pressure hose at the correct position.


*Deluxe Balloon Pressure Regulator*



*Pressure Regulator close up: A 28” grey plastic pipe with cap on one end and splash tape on the other. A white plastic hose that dips into the water to regulate the pressure. The grey pipe is filled with water to about 6” from the top.*

Aquarium plastic flexible tubing is used with T joiners for aquarium tubing, to connect an adjustable pressure regulator and also to a manometer. A manometer is a $30 device that measures pressure mostly used by commercial gas fitters.

To save time, 5 balloons are joined together with T connectors on the same line and are stretched at the same time. To seal the pressure line in the neck of the Chinese balloon I use a piece of white plastic ¼” water line. I wrap the neck of the balloon around this white line and then wrap it with 10 turns or more of a thin rubber band. The coil of rubber band is held from moving with a black spring paper clamp.

*Connection with balloon and air pressure that amazingly does not leak*

I have discovered that the process of stretching balloons is much easier and with less failure if the atmosphere is humid. I use 2 humidifiers in the room when stretching and try and achieve a 70% humidity. The higher the humidity in the room, the lower the pressure required for the balloons to stretch to a desired volume. The nylon material in the balloon membrane is more flexible when humid. I use a bent metal pipe to fit over the balloon to measure when the balloon has reached its desired volume. For further details on measuring this balloon volume check the nearby document **“Stretching Clear Chinese measuring rig”.** One balloon may explode in the process but it a good thing and will reveal a weak balloon. The air pressure is gradually raised over a number of hours, by adjusting the pressure regulator.

*Stretching begins to occur at about .3 psi depending on the humidity, and the pressure is slowly raised to about .55 psi or less while the physical dimensions of one of the balloons is regularly checked for volume. It is assumed that since all the balloons are slowly receiving the same pressure at the same time they will stretch to similar dimensions.*

*Humidity in the room showing 73% on the small digital gauge. This high humidity facilitates stretching.*

Previously, a check of all 5 balloons was done at the same time and were all about the same dimensions, so only one balloon is now monitored for dimensional change. When the target dimensions are obtained and the predetermined volume of about .17 cubic meters is reached, the pressure is lowered and maintained at about .25 psi for some hours to keep the balloon from contracting too quickly. After the pressure is lowered, the humidity is reduced, and the room door opened for dryer house air to be circulated through the room to dry out the balloons.

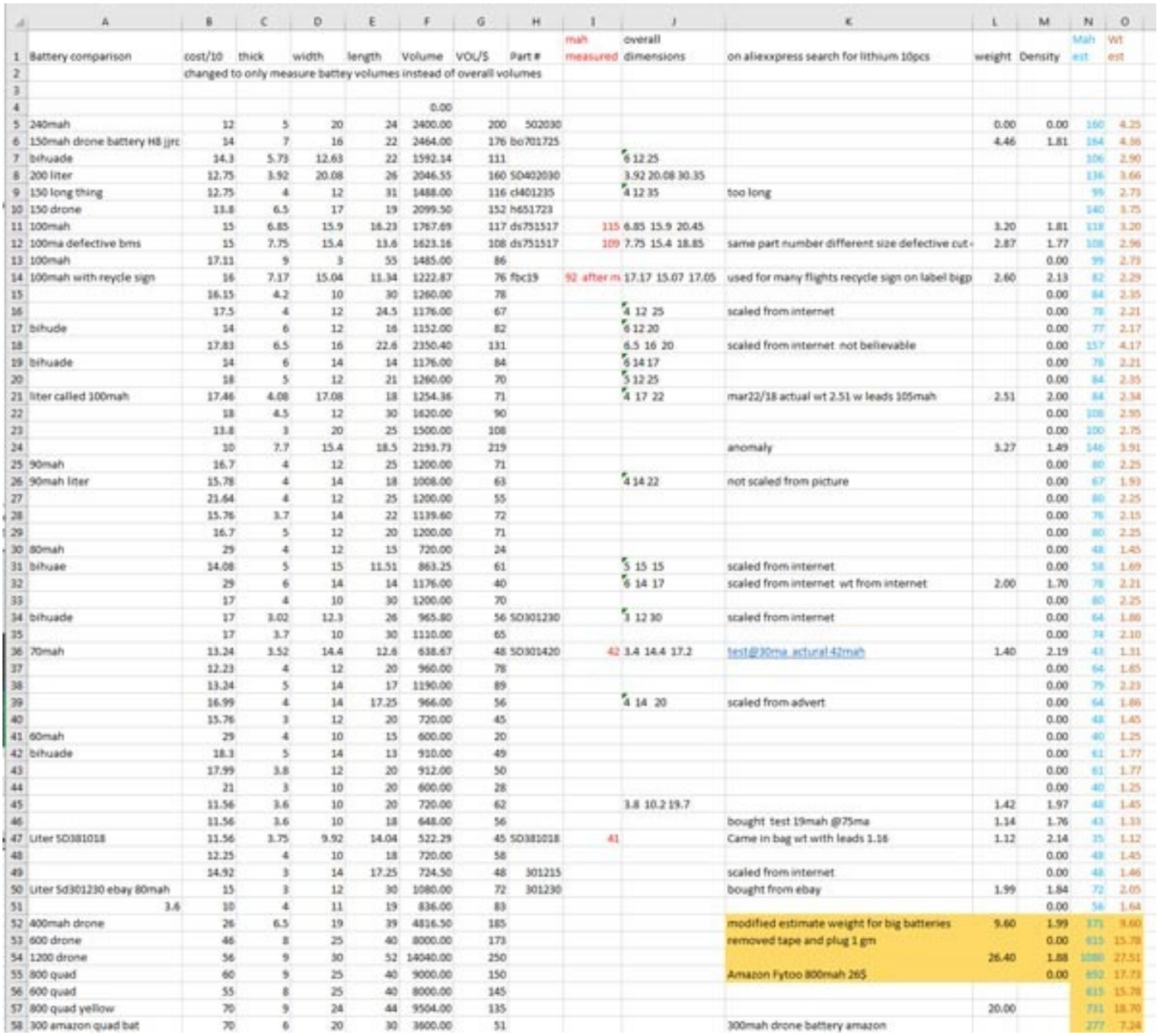
*Troubleshooting: It is unusual but sometimes there will be a pinhole leak in the balloon from the factory. If this is the case, the balloons being stretched will not increase in pressure past a certain amount. To find the offending balloon squeeze one balloon line at a time to restrict air flow to that balloon, and with the leaking balloon out of the circuit the other balloons will slowly increase in pressure as seen on the manometer.*

The balloon weighs about 35 grams and has a specific volume when it comes fresh out of the package. By stretching and increasing the volume of the balloon, the balloon's inflated density is decreased, because the stretched volume is larger than the original volume, but the weight is the same. The lower the density of the balloon and its payload, the higher float level the balloon will achieve. The difference between an unstretched balloon and a stretched one, can be from 10500 meters unstretched to12500 meters stretched, lifting the same payload weight.

## Battery life

There is a lot of variability in the type of lipo batteries available from Aliexpress. Since the characteristics of a lipo battery are often related to volume and weight or density, one can construct a spreadsheet to estimate the capacity from the published battery dimensions. Armed with a spreadsheet, one could usually

determine, by the dimensions of the battery, the expected mah capacity and estimate the battery weight. This can weed out battery products with exaggerated capacity claims before purchase.



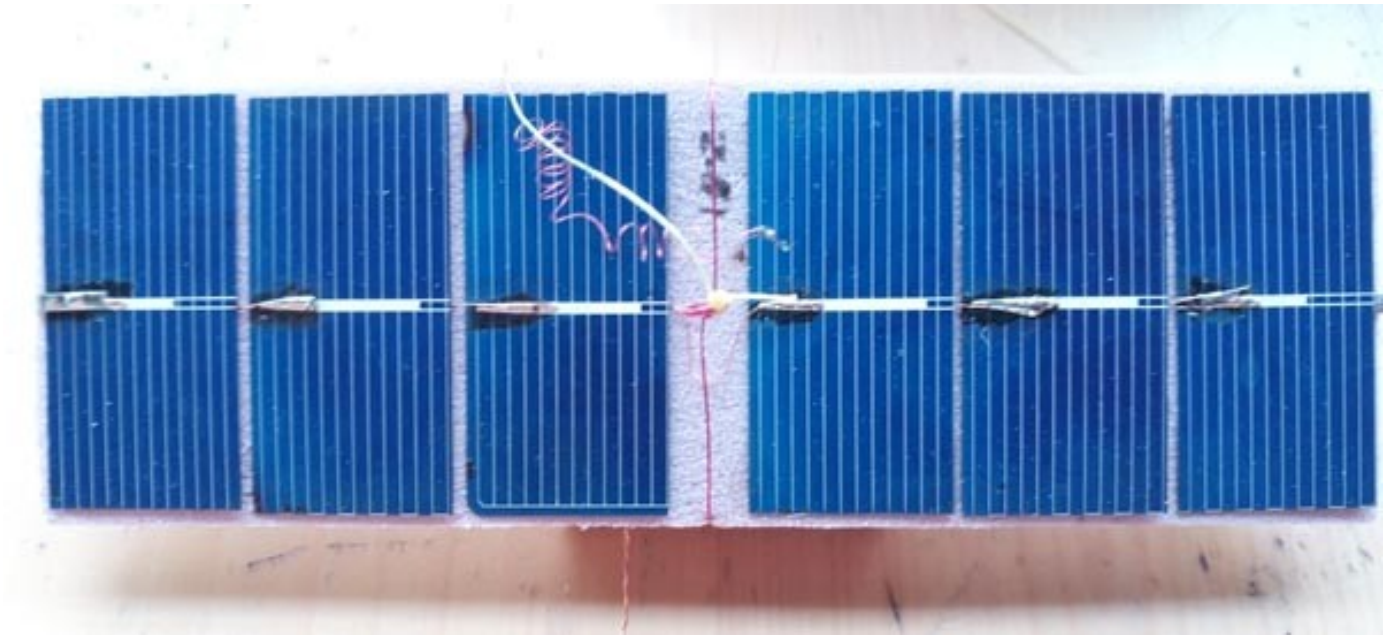
| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Battery comparison | cost/10 | thick | width | length | Volume | VOL/$ | Part # | mah measured | overall dimensions | on aliexpress search for lithium 10pcs | weight | Density | Mah est | Wt est |
| 2 | | changed to only measure battey volumes instead of overall volumes | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | | |
| 4 | | | | | | 0.00 | | | | | | | | | |
| 5 | 240mah | 12 | 5 | 20 | 24 | 2400.00 | 200 | 502030 | | | | 0.00 | 0.00 | 160 | 4.25 |
| 6 | 150mah drone battery H8 jjrc | 14 | 7 | 16 | 22 | 2464.00 | 176 | bo701725 | | | | 4.46 | 1.81 | 164 | 4.36 |
| 7 | bihuade | 14.3 | 5.73 | 12.63 | 22 | 1592.14 | 111 | | | 6 12 25 | | | | 106 | 2.90 |
| 8 | 200 liter | 12.75 | 3.92 | 20.08 | 26 | 2046.55 | 160 | SD402030 | | 3.92 20.08 30.35 | | | | 136 | 3.66 |
| 9 | 150 long thing | 12.75 | 4 | 12 | 31 | 1488.00 | 116 | cl401235 | | 4 12 35 | too long | | | 99 | 2.73 |
| 10 | 150 drone | 13.8 | 6.5 | 17 | 19 | 2099.50 | 152 | h651723 | | | | | | 140 | 3.75 |
| 11 | 100mah | 15 | 6.85 | 15.9 | 16.23 | 1767.69 | 117 | ds751517 | 115 | 6.85 15.9 20.45 | | 3.20 | 1.81 | 118 | 3.20 |
| 12 | 100ma defective bms | 15 | 7.75 | 15.4 | 13.6 | 1623.16 | 108 | ds751517 | 109 | 7.75 15.4 18.85 | same part number different size defective cut- | 2.87 | 1.77 | 108 | 2.96 |
| 13 | 100mah | 17.11 | 9 | 3 | 55 | 1485.00 | 86 | | | | | | 0.00 | 99 | 2.73 |
| 14 | 100mah with reycle sign | 16 | 7.17 | 15.04 | 11.34 | 1222.87 | 76 | fbc19 | 92 after m | 17.17 15.07 17.05 | used for many flights recycle sign on label bigp | 2.60 | 2.13 | 82 | 2.29 |
| 15 | | 16.15 | 4.2 | 10 | 30 | 1260.00 | 78 | | | | | | 0.00 | 84 | 2.35 |
| 16 | | 17.5 | 4 | 12 | 24.5 | 1176.00 | 67 | | | 4 12 25 | scaled from internet | | 0.00 | 78 | 2.21 |
| 17 | bihude | 14 | 6 | 12 | 16 | 1152.00 | 82 | | | 6 12 20 | | | 0.00 | 77 | 2.17 |
| 18 | | 17.83 | 6.5 | 16 | 22.6 | 2350.40 | 131 | | | 6.5 16 20 | scaled from internet not believable | | 0.00 | 157 | 4.17 |
| 19 | bihuade | 14 | 6 | 14 | 14 | 1176.00 | 84 | | | 6 14 17 | | | 0.00 | 78 | 2.21 |
| 20 | | 18 | 5 | 12 | 21 | 1260.00 | 70 | | | 5 12 25 | | | 0.00 | 84 | 2.35 |
| 21 | liter called 100mah | 17.46 | 4.08 | 17.08 | 18 | 1254.36 | 71 | | | 4 17 22 | mar22/18 actual wt 2.51 w leads 105mah | 2.51 | 2.00 | 84 | 2.34 |
| 22 | | 18 | 4.5 | 12 | 30 | 1620.00 | 90 | | | | | | 0.00 | 108 | 2.95 |
| 23 | | 13.8 | 3 | 20 | 25 | 1500.00 | 108 | | | | | | 0.00 | 100 | 2.75 |
| 24 | | 10 | 7.7 | 15.4 | 18.5 | 2193.73 | 219 | | | | anomaly | 3.27 | 1.49 | 146 | 3.91 |
| 25 | 90mah | 16.7 | 4 | 12 | 25 | 1200.00 | 71 | | | | | | 0.00 | 80 | 2.25 |
| 26 | 90mah liter | 15.78 | 4 | 14 | 18 | 1008.00 | 63 | | | 4 14 22 | not scaled from picture | | 0.00 | 67 | 1.93 |
| 27 | | 21.64 | 4 | 12 | 25 | 1200.00 | 55 | | | | | | 0.00 | 80 | 2.25 |
| 28 | | 15.76 | 3.7 | 14 | 22 | 1139.60 | 72 | | | | | | 0.00 | 76 | 2.15 |
| 29 | | 16.7 | 5 | 12 | 20 | 1200.00 | 71 | | | | | | 0.00 | 80 | 2.25 |
| 30 | 80mah | 29 | 4 | 12 | 15 | 720.00 | 24 | | | | | | 0.00 | 48 | 1.45 |
| 31 | bihuae | 14.08 | 5 | 15 | 11.51 | 863.25 | 61 | | | 5 15 15 | scaled from internet | | 0.00 | 58 | 1.69 |
| 32 | | 29 | 6 | 14 | 14 | 1176.00 | 40 | | | 6 14 17 | scaled from internet wt from internet | 2.00 | 1.70 | 78 | 2.21 |
| 33 | | 17 | 4 | 10 | 30 | 1200.00 | 70 | | | | | | 0.00 | 80 | 2.25 |
| 34 | bihuade | 17 | 3.02 | 12.3 | 26 | 965.80 | 56 | SD301230 | | 3 12 30 | scaled from internet | | 0.00 | 64 | 1.86 |
| 35 | | 17 | 3.7 | 10 | 30 | 1110.00 | 65 | | | | | | 0.00 | 74 | 2.10 |
| 36 | 70mah | 13.24 | 3.52 | 14.4 | 12.6 | 638.67 | 48 | SD301420 | 42 | 3.4 14.4 17.2 | test@30ma actural 42mah | 1.40 | 2.19 | 43 | 1.31 |
| 37 | | 12.23 | 4 | 12 | 20 | 960.00 | 78 | | | | | | 0.00 | 64 | 1.85 |
| 38 | | 13.24 | 5 | 14 | 17 | 1190.00 | 89 | | | | | | 0.00 | 79 | 2.23 |
| 39 | | 16.99 | 4 | 14 | 17.25 | 966.00 | 56 | | | 4 14 20 | scaled from advert | | 0.00 | 64 | 1.86 |
| 40 | | 15.76 | 3 | 12 | 20 | 720.00 | 45 | | | | | | 0.00 | 48 | 1.45 |
| 41 | 60mah | 29 | 4 | 10 | 15 | 600.00 | 20 | | | | | | 0.00 | 40 | 1.25 |
| 42 | bihuade | 18.3 | 5 | 14 | 13 | 910.00 | 49 | | | | | | 0.00 | 61 | 1.77 |
| 43 | | 17.99 | 3.8 | 12 | 20 | 912.00 | 50 | | | | | | 0.00 | 61 | 1.77 |
| 44 | | 21 | 3 | 10 | 20 | 600.00 | 28 | | | | | | 0.00 | 40 | 1.25 |
| 45 | | 11.56 | 3.6 | 10 | 20 | 720.00 | 62 | | | 3.8 10.2 19.7 | | 1.42 | 1.97 | 48 | 1.45 |
| 46 | | 11.56 | 3.6 | 10 | 18 | 648.00 | 56 | | | | bought test 19mah @75ma | 1.14 | 1.76 | 43 | 1.33 |
| 47 | Liter SD381018 | 11.56 | 3.75 | 9.92 | 14.04 | 522.29 | 45 | SD381018 | 41 | | Came in bag wt with leads 1.16 | 1.12 | 2.14 | 35 | 1.12 |
| 48 | | 12.25 | 4 | 10 | 18 | 720.00 | 58 | | | | | | 0.00 | 48 | 1.45 |
| 49 | | 14.92 | 3 | 14 | 17.25 | 724.50 | 48 | 301215 | | | scaled from internet | | 0.00 | 48 | 1.46 |
| 50 | Liter Sd301230 ebay 80mah | 15 | 3 | 12 | 30 | 1080.00 | 72 | 301230 | | | bought from ebay | 1.99 | 1.84 | 72 | 2.05 |
| 51 | 3.6 | 10 | 4 | 11 | 19 | 836.00 | 83 | | | | | | 0.00 | 56 | 1.64 |
| 52 | 400mah drone | 26 | 6.5 | 19 | 39 | 4816.50 | 185 | | | | modified estimate weight for big batteries | 9.60 | 1.99 | 371 | 9.60 |
| 53 | 600 drone | 46 | 8 | 25 | 40 | 8000.00 | 173 | | | | removed tape and plug 1 gm | | 0.00 | 615 | 15.78 |
| 54 | 1200 drone | 56 | 9 | 30 | 52 | 14040.00 | 250 | | | | | 26.40 | 1.88 | 1080 | 27.51 |
| 55 | 800 quad | 60 | 9 | 25 | 40 | 9000.00 | 150 | | | | Amazon Fytoo 800mah 26$ | | 0.00 | 692 | 17.73 |
| 56 | 600 quad | 55 | 8 | 25 | 40 | 8000.00 | 145 | | | | | | | 615 | 15.78 |
| 57 | 800 quad yellow | 70 | 9 | 24 | 44 | 9504.00 | 135 | | | | | 20.00 | | 731 | 18.70 |
| 58 | 300 amazon quad bat | 70 | 6 | 20 | 30 | 3600.00 | 51 | | | | 300mah drone battery amazon | | | 277 | 7.24 |

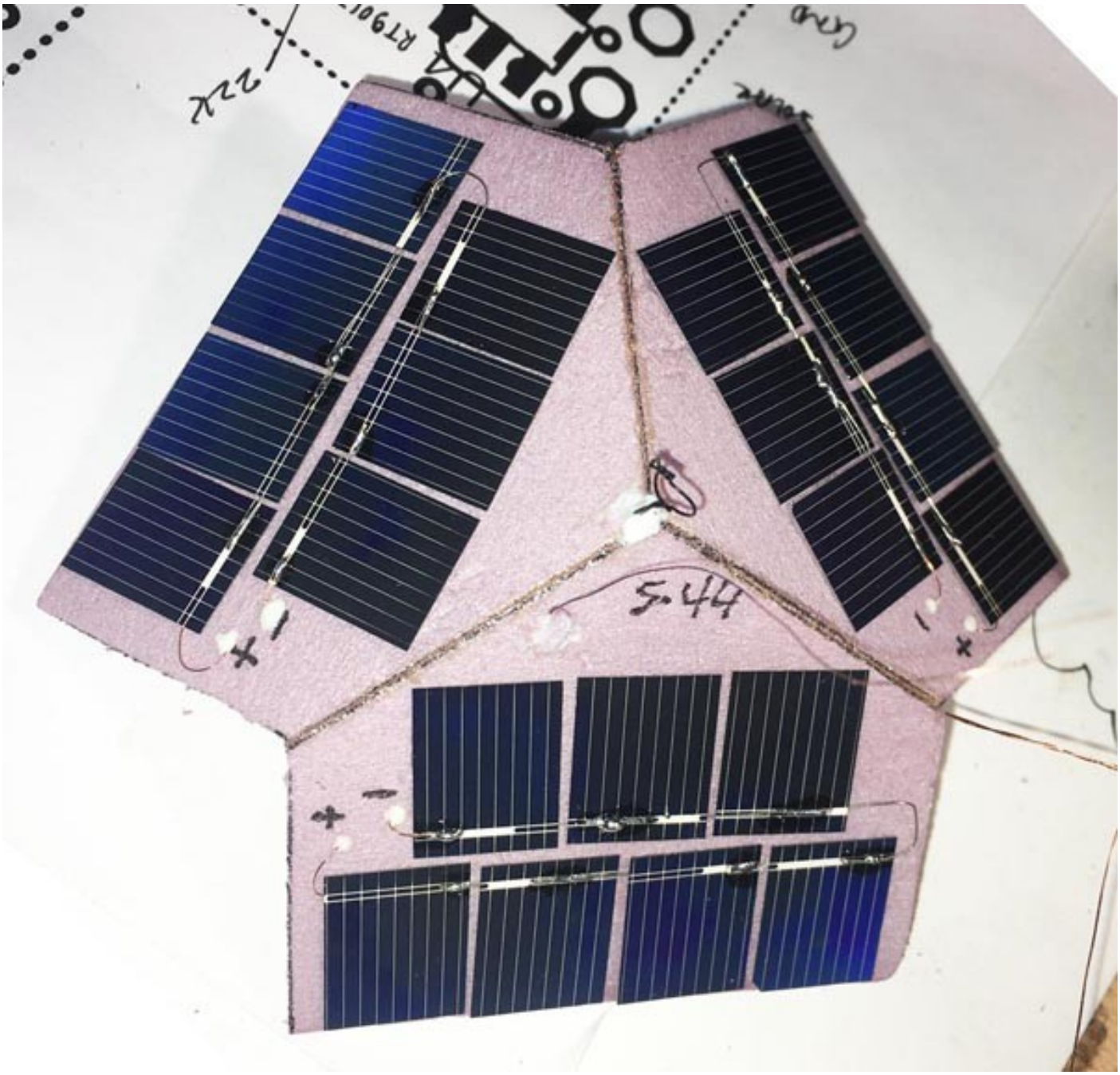
*Lipo battery comparison table*

In early flights, attempts to have the transmitter turn on at night and transmit its position were not successful. The battery sometimes was able to transmit for as long as 4 hours after normal solar powered transmission would have ceased, and at temperatures as low as -30c. It was noticed that physical characteristics like fat or thick lipos did much better in capacity in the cold when compared to long thin shaped lipo batteries. At some point, it may be possible to utilize some of the battery power to heat an insulated box containing the battery and radio. If the battery is big enough and the insulation light enough an all-night transmission could be possible. Experiments were done by transmitting on a longer spaced transmission schedule, so less battery power was consumed but this mode did not work well. This process consumed less power and made less internal heat so the temperature dropped at a faster rate and the battery failed from the cold earlier than using more frequent transmissions. As the battery gets colder the internal resistance gets larger and the voltage decreases under load to a point when there is not enough voltage to run the radio.

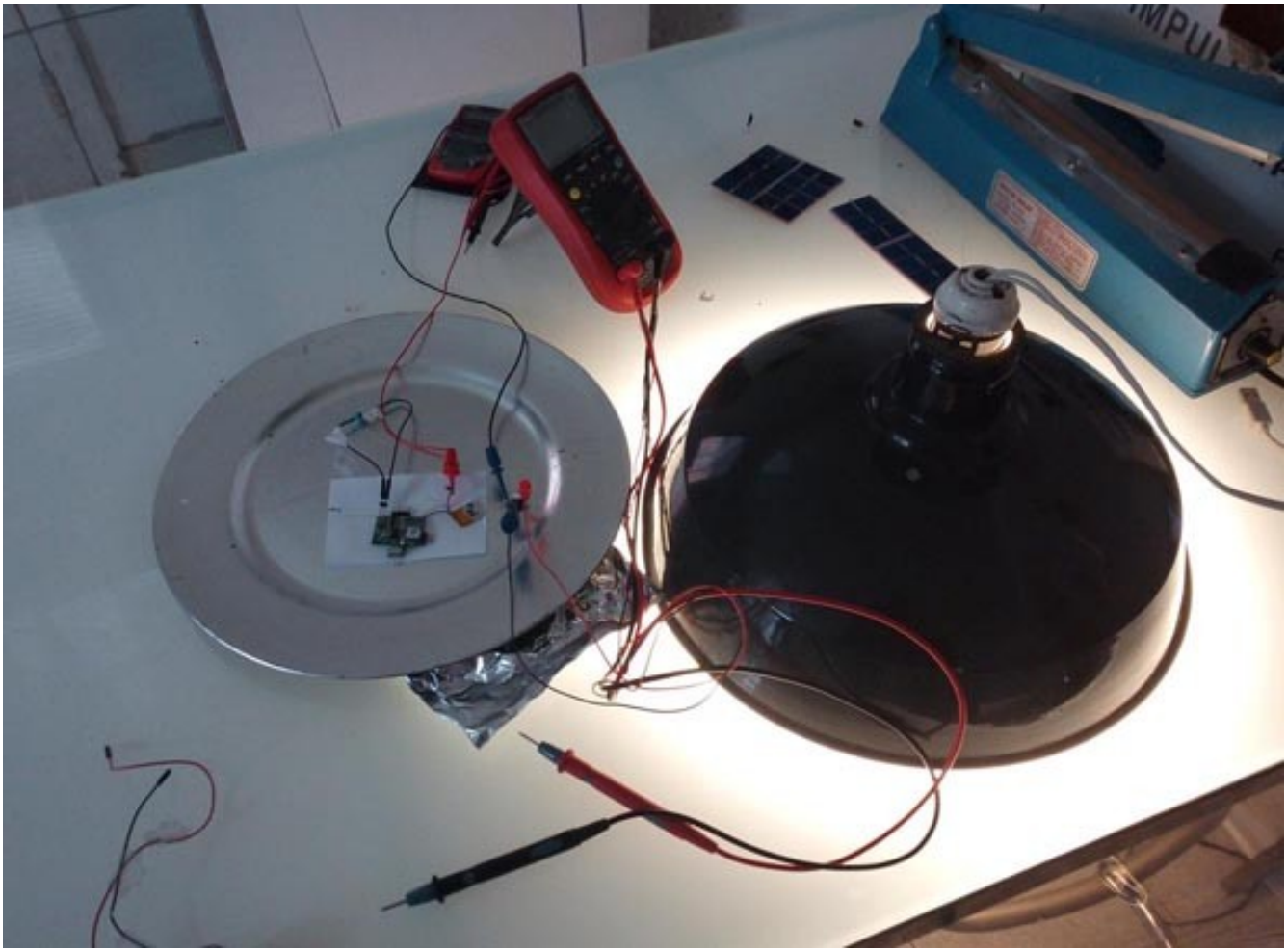
## Solar cells and Foam

Solar cells are about .2mm thick and are quite fragile. Soldering wires to the solar cells is difficult and overheating can crack the cell or burn up the solderable metal surface on the bottom of the cell. One soldering trick I use is to set the iron to 320c and hold a piece of clean multi-core solder over the white soldering section of the solar cell. The pre-tinned  soldering tip is then quickly swiped over the piece solder as it is attached to the solar cell. After the cell solder strip is primed with solder, the addition of joining wires is easier. Recently, tinned 36g magnet wire is used to join the cells together and green contact cement to attach the cells to a foam backing.



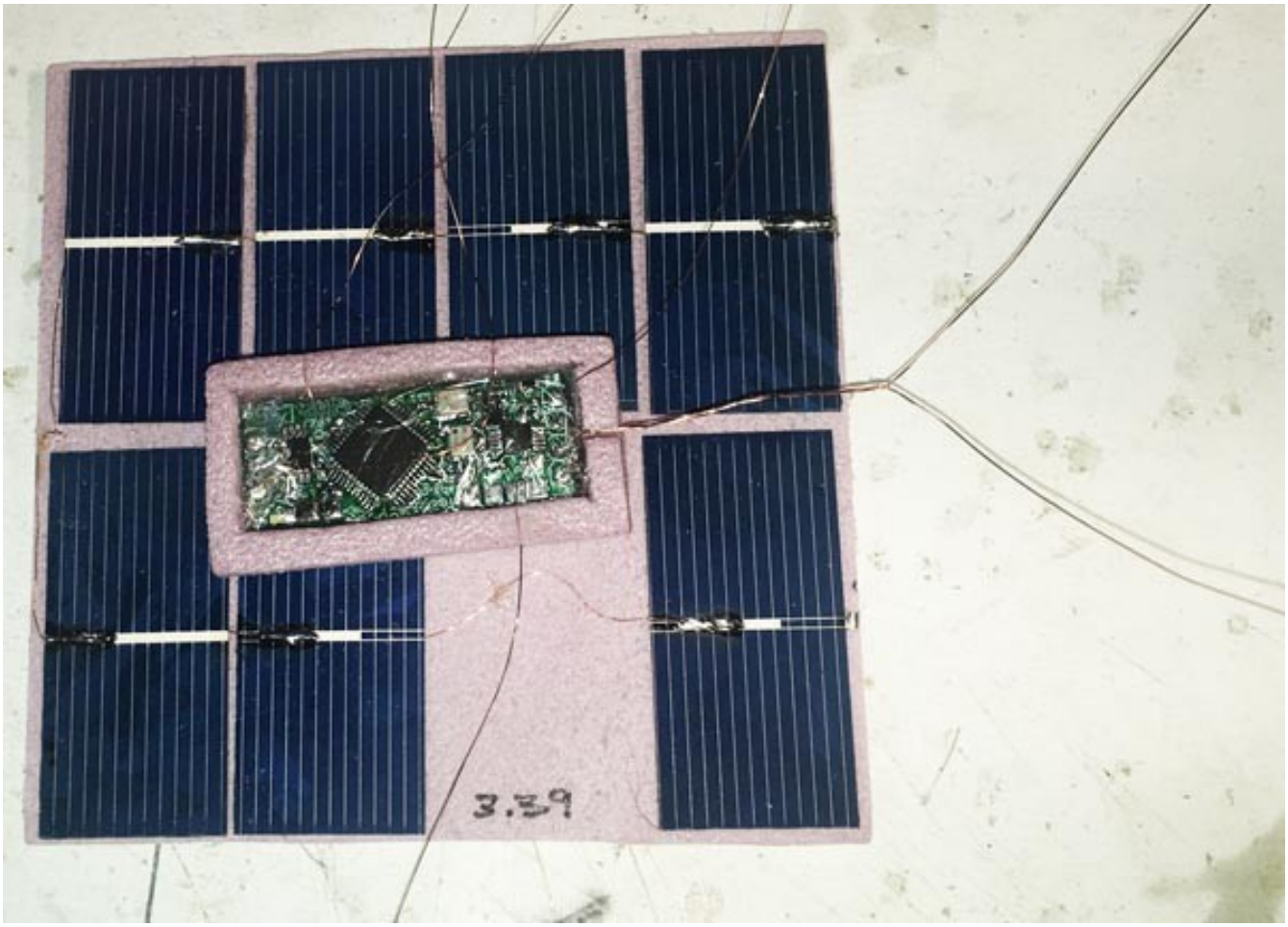



*Different solar panel configurations and tests*

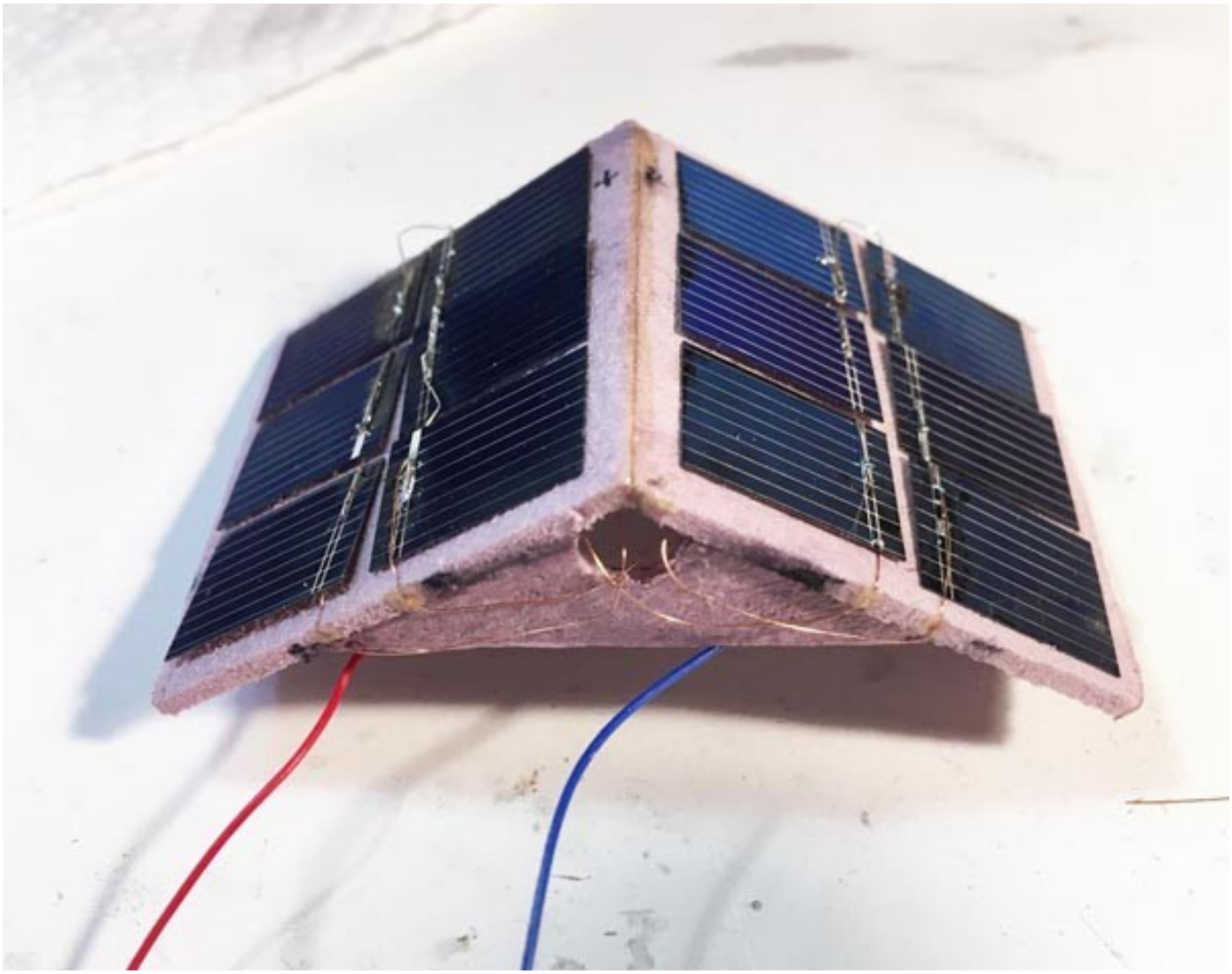


*Testing a prototype U4B with various solar cell combinations*


*Grow lamp made lots of light to run the solar cells, but also generated too much RFI for the gps to lock*

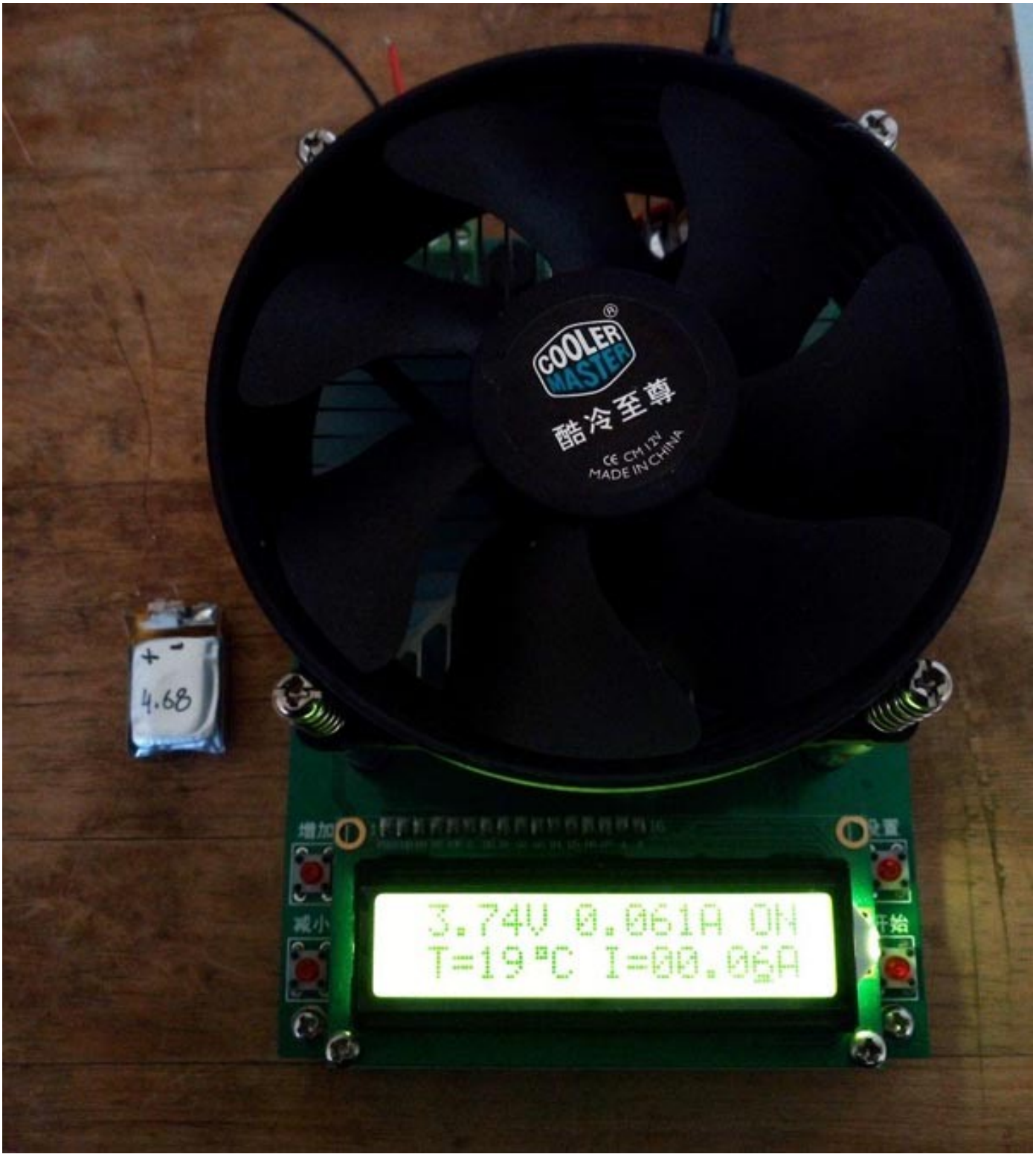



*Detail above showing foam box and U4B wrapped in plastic before being glued to the underside of the solar panel*



*A roof shaped panel was tried with a magnet to orient the ridge north and south this system did not work well for me*

*A Neo magnet was used to orient the ridge of the solar collector north and south. Blocking diodes glued down*




*Testing a candidate Lipo battery weight 4.68 grams @ 60ma discharge rate.*

I use pink construction foam that is wire cut into sheets of different thicknesses. The solar cell foam panel will also serve as the top of the foam radio box. The gluing of the connected cells to the foam is rather delicate as one does not want to get glue on the top surface of the solar cell. The technique now used is to take the bare soldered cell assembly and place upside down on a piece of foam that is the exact same size of the foam section they are to be glued to.


More Options Available

**LePage** Low Odour Contact Cement, 237 ml

*I find this green contact cement does not damage foam and is very useful on antenna construction and everywhere*

Green contact cement is applied to the high sections of the underside of the cells (the cells never lay flat due to the connection wires) as the high sections of the back of the solar cells will be the parts that touch the foam where it attaches. After the glue is applied, the foam base is put on the top of the solar cells glued side, and the two pieces of foam with cells in between is inverted. The cells are now the right way up,

loosely glued to the foam base and just a slight movement with a toothpick or similar can arrange the solar cells perfectly on the foam base.


*Assembly for U4B-29 (using a S.A.G. balloon) weighs in. Currently floating at 14km*

*Using a food container to do solar roof testing of a U4B*

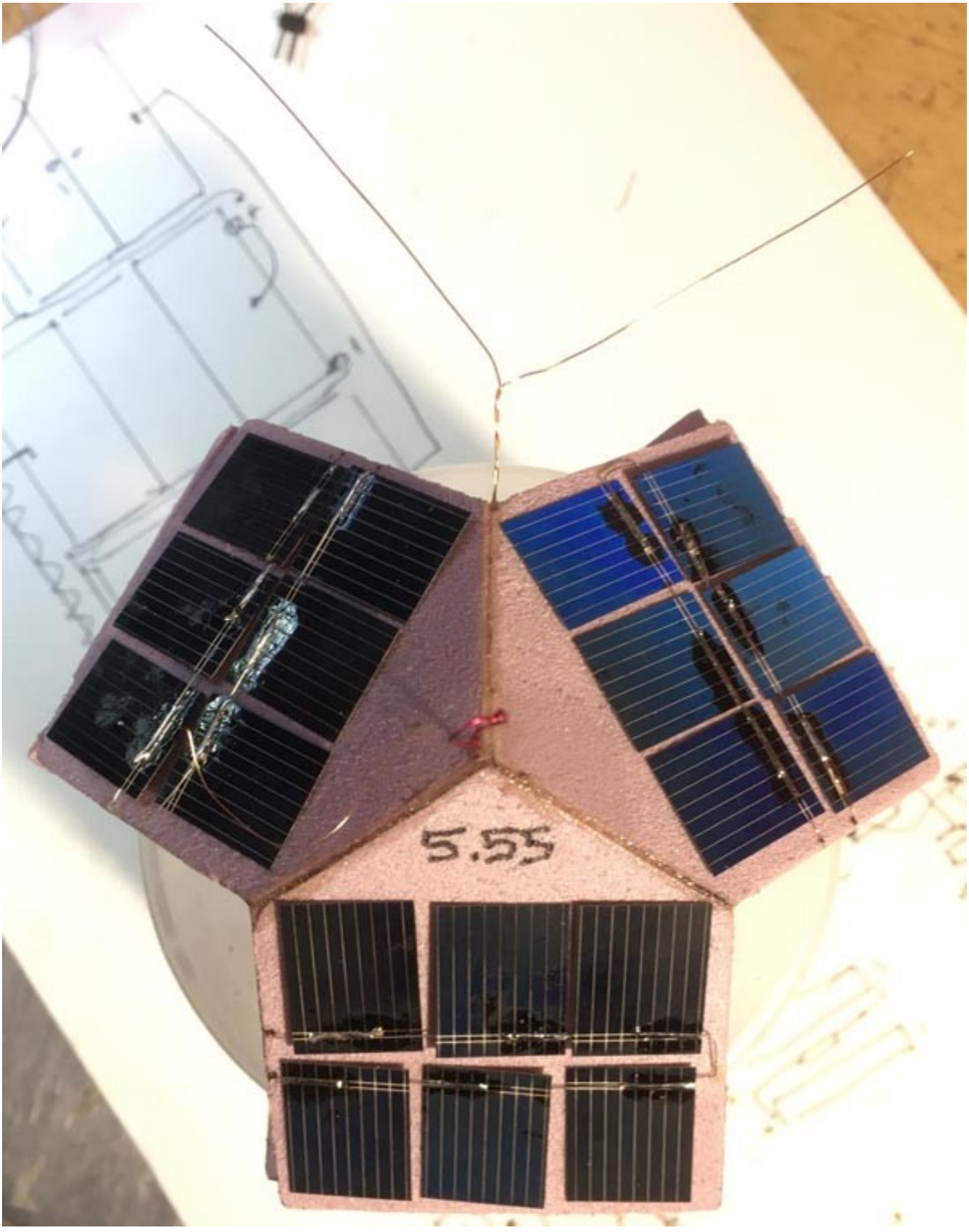
The cement is usually dry in 10 15 minutes. After drying the solar panel is tested in the sun for full short circuit current. It is tested again with a suitable load resistor to draw about 60 ma. in full sun (transmitter consumption in high power mode) and then checked by rotation to record at what angle the solar panel does not produce a working voltage.

| solar angle | 10x52 x7 cells | | |
|---|---|---|---|
| | Voltage | Current | power W |
| | 62 ohm load(high power) | | |
| 0 | 1 | 0.016 | 0.016 |
| 5 | 1.7 | 0.029 | 0.049 |
| 10 | 2.1 | 0.034 | 0.071 |
| 15 | 2.9 | 0.046 | 0.133 |
| 20 | 3.45 | 0.056 | 0.193 |
| 30 | 3.8 | 0.062 | 0.236 |
| | | | |
| | 90 ohm load(low power) | | |
| 0 | 1.2 | 0.013 | 0.016 |
| 5 | 1.7 | 0.019 | 0.032 |
| 10 | 2.4 | 0.027 | 0.065 |
| 15 | 3.3 | 0.038 | 0.125 |
| 20 | 3.7 | 0.041 | 0.152 |
| 30 | 3.9 | 0.044 | 0.172 |

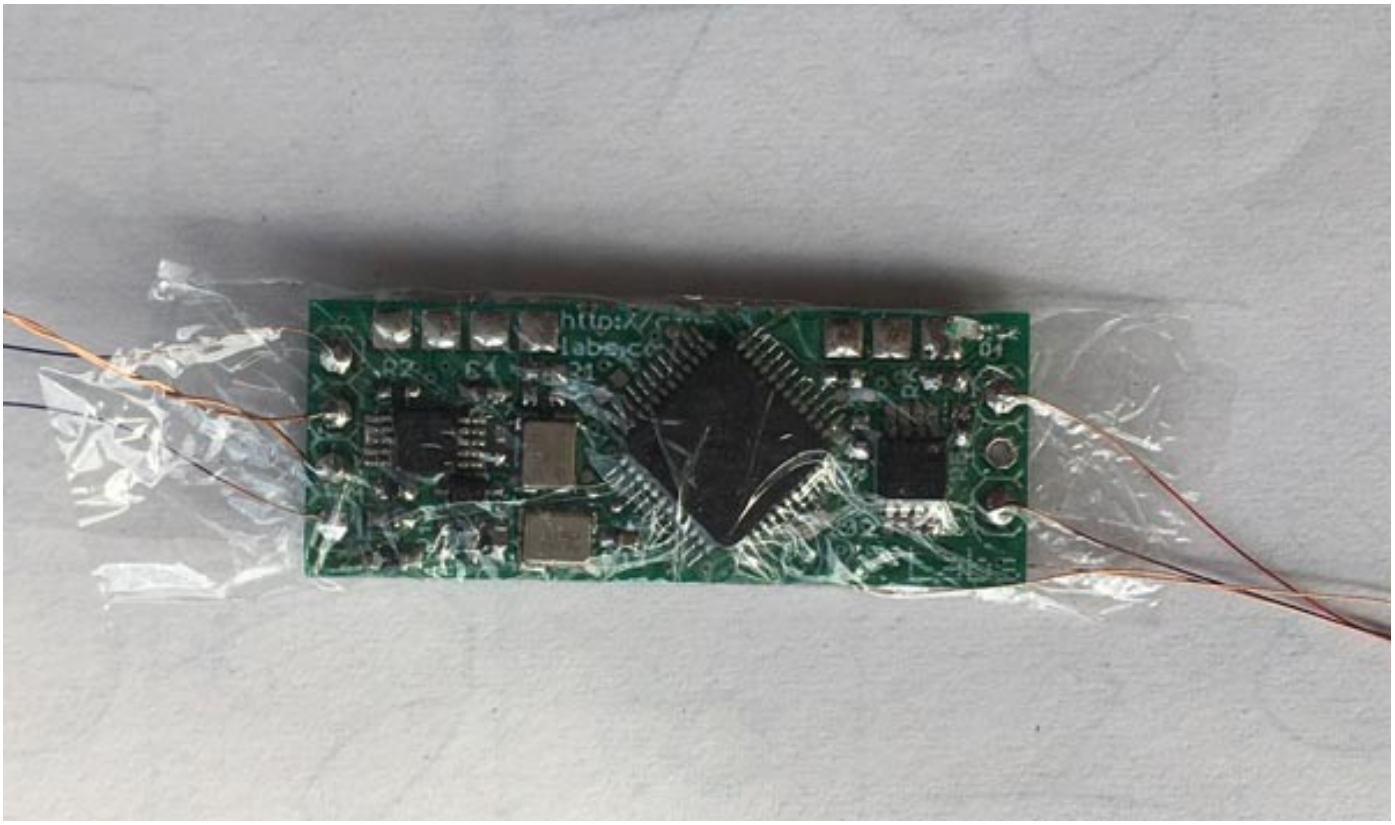
| solar angle | 19x39 x7 cells | | |
|---|---|---|---|
| | Voltage | Current | power |
| | 62 ohm load(high power) | | |
| 0 | 2 | 0.032 | 0.064 |
| 5 | 2.3 | 0.038 | 0.087 |
| 10 | 2.9 | 0.048 | 0.139 |
| 15 | 3.52 | 0.057 | 0.201 |
| 20 | 3.73 | 0.061 | 0.228 |
| 30 | 3.9 | 0.064 | 0.250 |
| | | | |
| | 90 ohm load(low power) | | |
| 0 | 1.7 | 0.019 | 0.032 |
| 5 | 2.2 | 0.025 | 0.055 |
| 10 | 3 | 0.034 | 0.102 |
| 15 | 3.5 | 0.04 | 0.140 |
| 20 | 3.7 | 0.042 | 0.155 |
| 30 | 3.9 | 0.044 | 0.172 |

*Some test results with two sizes of solar cells at different angles to the sun with different loads in bright sun. These numbers can be increased by about 20% in the cold at float level.*

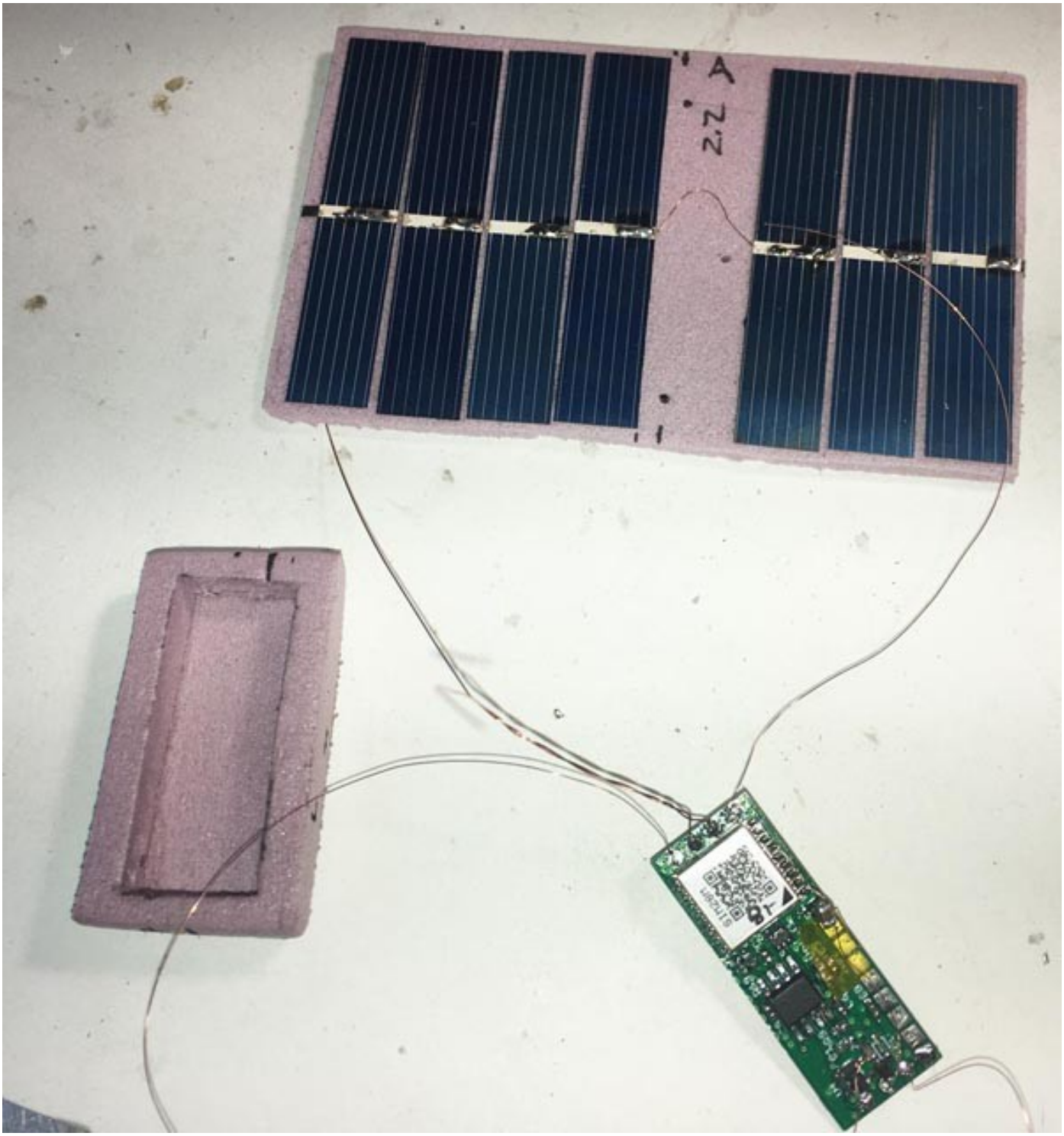
The flat solar cells should work down to about a solar elevation of about 12 to 16 degrees, while a pyramid shape can work down to 7 degrees or less.



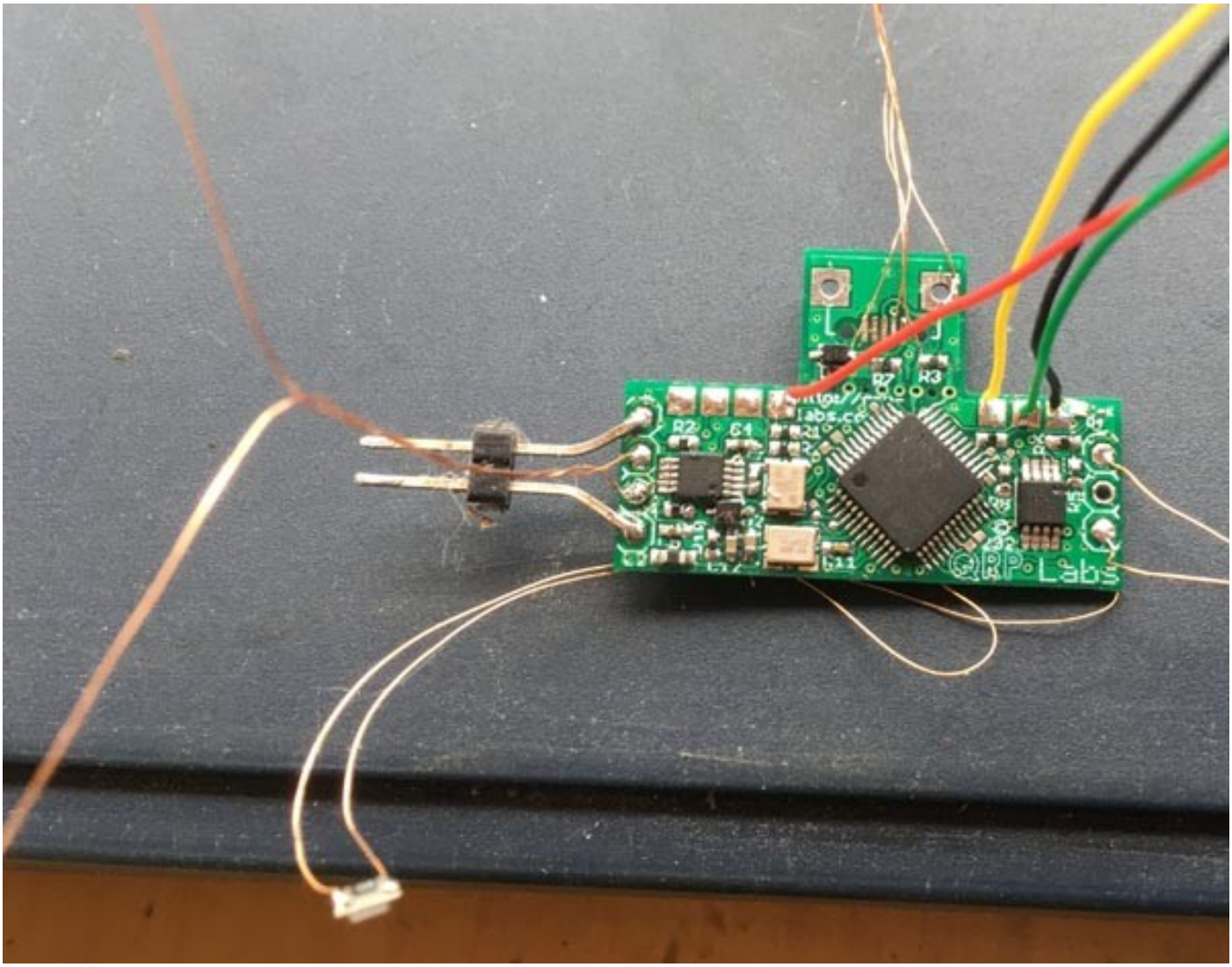

*Pyramid solar panel cell wiring detail*



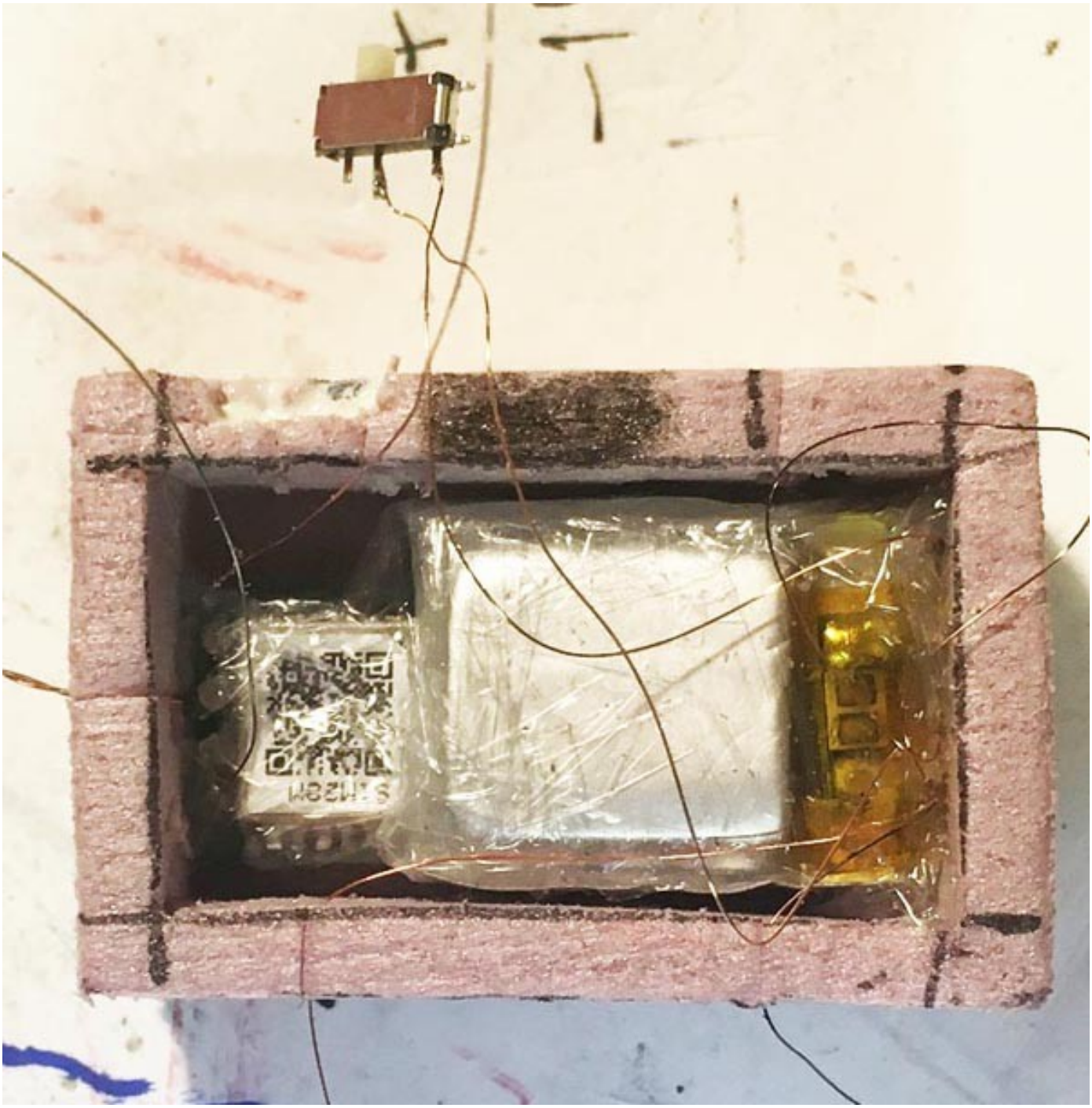
*Wires leaving the wrapped U4B before dropping in a foam box and gluing it to the underside of the solar panel*




*Some pre assembly parts. Cuts are made in the foam box (not shown) to lead the wires out below the glue line.*




*The U4B programming is tested to make sure the Basic program works. The left-hand connector is for an easy plugin 50-ohm load and the led sensor with dampening resistor is hanging out front. A prototype U4B, the coloured programming wires are visible.*



*A battery flight with switch to be glued into the notch in the foam ( the lipo has an individual plastic wrapping in case of bad things ) Wires are led out though cuts in the foam walls. The lipo battery has a protection circuit visible on the right of the cell*

Bob Sutton in New Zealand was the first I know of to use 3 sets of solar panels placed 120 degrees apart and was able to transmit from sunrise to sunset which could extend the transmission day from 2 to 3 hours. Other solar cell techniques have been tried by Mikael Dagman in Sweden, using a magnet to orient one side of the solar panel to North and sloping the other side of the panel to the south. This method has been reported to work well in the winter when the sun is always shining between the south east and south west directions, and will extend the transmission day by operating much closer to the horizon at sunrise and sunset. A small version of the pyramid collector with 18 small solar cells was used and worked down to about 7 degrees of sun. All test flights used foam to support the solar cells and foam to encase the U4B to avoid direct sunlight on the components. The foam provides some insulation and reported temperatures in the U4B are usually around room temperature most of the day. No testing was done with direct sun on the components of the U4B. As the radio rotates, the components on the pcb could experience quite rapid temperature changes if not protected from the sun, which may not be good for frequency stability.

## 20 Meter Antenna

The U4B uses a vertical dipole cut for 20 m and the U4B is located between the upper and lower dipole elements. The wire used in the U4B series is 42-gauge magnet wire and this is very weak but light. To make the antenna more robust, the wire dipole element is glued to a 6-pound Dyneema (Kevlar) fishing line that is very strong and light weight. The construction of the antenna is made in a hallway and strung between a few wood screws in the woodwork. Screws are at a distance of ¼ wavelength for 20m, or about 5 meters apart. Green masking tape is used in the construction process to hold the wires or fishing line ends. First the Dyneema is strung between the two wood screws and 4” ends bent down at 90 degrees and fastened with tape. The magnet wire is installed on top of the fishing line making sure it is tensioned so the lines are touching and parallel and the wire ends are also bent down at 90 degrees and taped on top of the Dyneema. Then I use green contact cement (the type that can glue foam) and take a dab of cement between finger and thumb and wipe it over the wire and line bonding them together for about 2 feet either end of the dipole to about ½” from the screw, so the line and wire is glued solidly in that area. The remaining middle section of the antenna is glued at about 1-foot intervals by putting cement between thumb and finger and then touching the antenna wire and fishing line at intervals. The lower element is now made the same way. Repeating, the wood screws are about 5 meters apart and there is about 4 or so inches of extra wire and line at either end that is not glued but is held by tape. A black magic marker is used on the glued end of the antenna wires just inboard of the wood screws to mark a line on the antenna that that will indicate the proper length of the antenna for soldering and attachment to the U4B.

Antenna rolls are constructed from heavy printer paper and are rolled so they are about 8.5 inches long and about 2 inches in diameter. These rolls are then taped with wide clear tape at either ends. To take up the tension on the antenna wire while it is rolled up, a strip of flexible white packing foam about ½” wide is glued lengthwise on the surface of the rolls.

*Antenna roll with foam strip to keep wire in tension*

Each roll has 4 small pieces of green masking tape attached and is weighed on a .01 gram scale and one piece of tape is marked with TARE and the weight of the roll without the antenna. One roll is marked Top and the other Bottom. The Top roll is used from the radio to the balloon and the Bottom roll hangs down from the radio. The clear tape at the roll ends makes attaching and removing the antenna wire simpler, as the green masking tape, used to secure the antenna wire ends does not damage the paper roll when being removed. One end of each roll is marked Radio. When the antenna glue is dry it is rolled up onto the paper roll. One end of the antenna wire is fastened with one of the pieces of green masking tape and it is started from the end opposite to the Radio end. The roll is then rotated winding the antenna onto the roll, trying to keep the wires spaced till the Radio end is reached. The end of the wire is fastened with the attached tape piece. The finished antenna is then weighted and the weight of the antenna which is the final weight minus the TARE is written on the green masking tape. One leg of an antenna is usually about .3 grams. The total antenna weighs about .6 grams using this method. With radio construction, since the antenna wire is so

thin and fragile, a tight coil of the antenna wire at the radio end of the roll is wound to absorb shocks. This is coil is made on a small Phillips screw driver before soldering.


*Small coil of antenna wire and soldering detail ..wires glued so they cannot shake loose  led downfacing sensor glued down*

At the Radio end of the antenna roll, a black magic marker line will show the position of line to be tied to the support loop on the radio for fastening. The Dyneema and wire is separate from the wire for the last 4 inches or so, and only the Dyneema is tied to the radio support loop at the end of the black maker line. After the Dyneema is tied to the support loop, the excess line cut off and the knot on the loop is glued. About 10 turns of about 1/8” or less diameter coil is formed on the end of the antenna wire and soldered to the larger diameter wires connected to the U4B antenna lines. The loose end of the shock absorber coil of thin wire, that was formed, needs to be tinned and soldered to the U4B antenna wiring. The tinned ends of

the antenna coils are then soldered to the wire stubs for the antenna coming from the U4B. This fine wire soldering is very fiddley, so the solder joints are always glued with green contact cement afterwards.

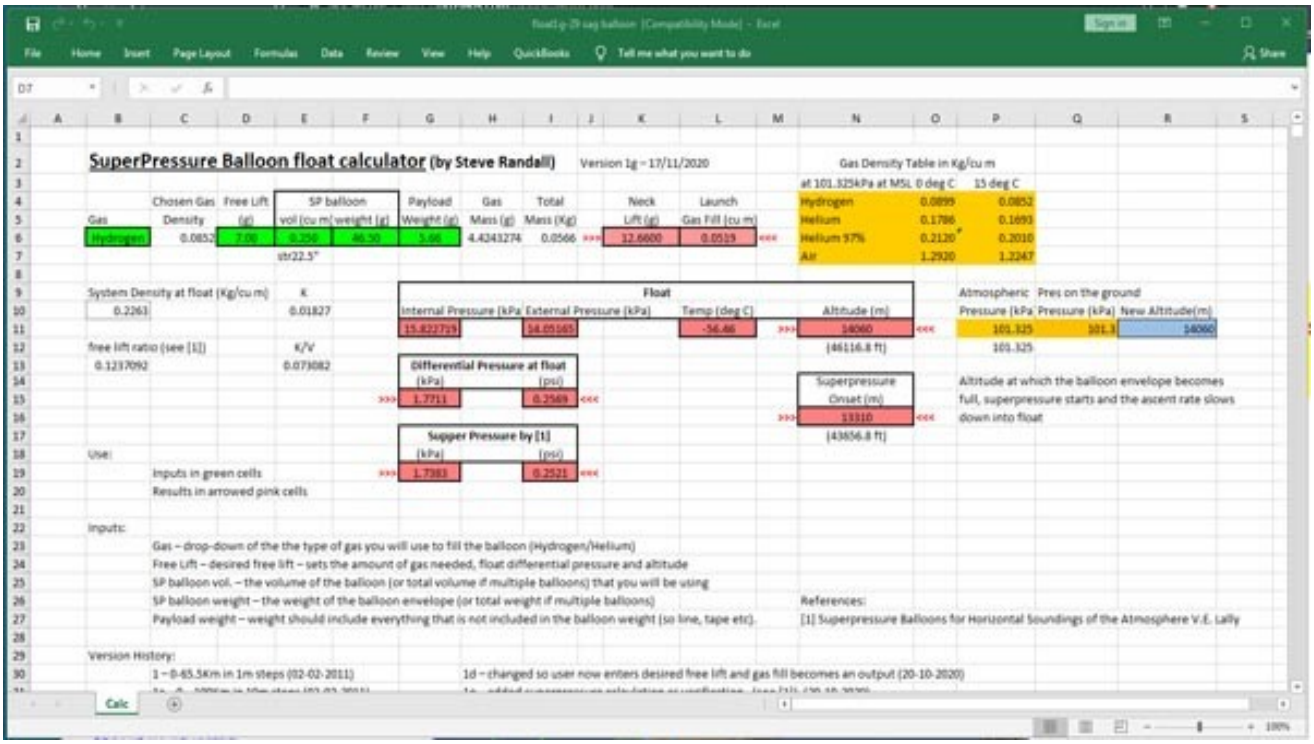
## Wire loops

The loops and support wire are constructed from 30-gauge coated wire found in craft supplies for beading and other handicrafts. The support wire on the U4B if fabricated by starting from the bottom side as a small loop and is then twisted tightly for about ½" and travels around the foam box below the solar panel and then up through holes in the solar panel gaps. On the top of the solar panel, it is twisted for about an inch and then formed into a small loop above the radio. The holes in the foam of the solar panel for the support wires are filled with glue and small dabs of glue hold the support wire onto the base of the foam box. After the radio ends of the upper and lower dipoles are attached and soldered to the radio antenna stubs, because the way the antenna was wound on the rolls, it will unroll smoothly at the launch site. The radio and antenna rolls are placed in the shoe box with foam padding for safe keeping. The U4B should be tested on a sunny day before flying to confirm it works. If sun hits the solar panel in the shoe box, it should transmit even with the antenna rolled up and be received at your home station.

## Launch day

It is advisable to check the weather forecast to find a good cloudless day for the balloon launch. The safest wind speed for a launch is no wind at all or dead calm. This calm condition is very rare but usually winds are lighter just before dawn. Dawn is the preferred time to let a balloon go. The weather forecast is checked a few hours before filling and sealing the balloons. One can also check the wind speed and direction from data at the nearest airport. This information is usually available on the internet. It is not a good idea to launch a balloon, if the wind speed is any higher than 5 knots or about 6 miles per hour.

On an Excel spreadsheet created by Steve Randall, and downloadable on Habhub, one can enter many variables of the flight. These include the mass of the balloon, the amount of free lift, and the payload, (the weight of the radio, antenna, and solar panels). The spreadsheet can determine the differential pressure in the balloon at the float level. (the differential pressure is the difference between pressure inside the balloon and outside the balloon.) If that pressure is too high it will cause the balloon to burst. Adding too much extra lifting gas to the balloon (too much free lift) can create a high differential pressure and cause the balloon to fail.



At the launch, the balloon and its payload is less dense than the surrounding air, so the clear balloons rise at about 600 meters every 10 minutes, or every Wspr transmission. As the balloon climbs the air gets thinner and the balloon gradually expands, but at the float level the balloon cannot expand any further so the balloon and payload's density becomes constant and equal to the density of the surround air. Recently with 2 clear balloons, this equilibrium happens somewhere around 11 to 12 kilometers above the earth depending on the payload weight.

Other influences affect the float level of the balloon. The pressure at 12 km above earth varies differently to pressure on the earth. The balloon float level is influenced by its surrounding pressure and air temperature. The pressure level at about 12km above the earth is approximately 200 Hpa or hectopascals and on earth it is about 1013 hectopascals. Float air pressure is about 1/5$^{th}$ of the air pressure at sea level. If the pressure trends higher at the 12km level the balloon will fly higher. If the pressure is lower at 12km the balloon will float lower. The temperature at float level can vary from -42c to -70c and this affects the float level of the balloon. If the temperature is in the low range of -65c, the air is denser, and will make the balloon fly higher. If the temperature at float level is a balmy -45c the surrounding air will be less dense and the balloon will float at a lower altitude.

The jet stream is a highspeed wind that exists around the world in a serpentine pattern. In the Northern Hemisphere it usually blows from the west to the east. Some balloons have seen the jet stream carry the balloon at over 150 knots per hour (277 km/hr.). In the U4B, Wspr type of balloon transmitter, there is some evidence that there is a parasitic drag on the balloon radio and long antenna assembly, hanging below the balloon, that makes the balloon fly noticeably lower in a high-speed jet stream.

The wind direction is important, as sometimes the launch site has trees nearby that could interfere with the balloon's clear ascent path. Two different sites are used in Toronto. One that favours the prevailing wind, and one that is used when the wind is coming from the opposite direction. Often a day with low wind, has the wind changing direction on that day, but usually the weather forecast will indicate which way the wind direction should be changing over time. If the launch space is big enough, one does not have to worry about the wind direction. One location nearby has about 150 meters or almost 500 feet clear with low trees at either end, and the other, at the edge of a lake, is wide open for miles in the direction of the prevailing winds. Unfortunately, the lake site has dogs and dog walkers and runners and a number of moving hazards that could cause a problem with the very fine antenna wire.

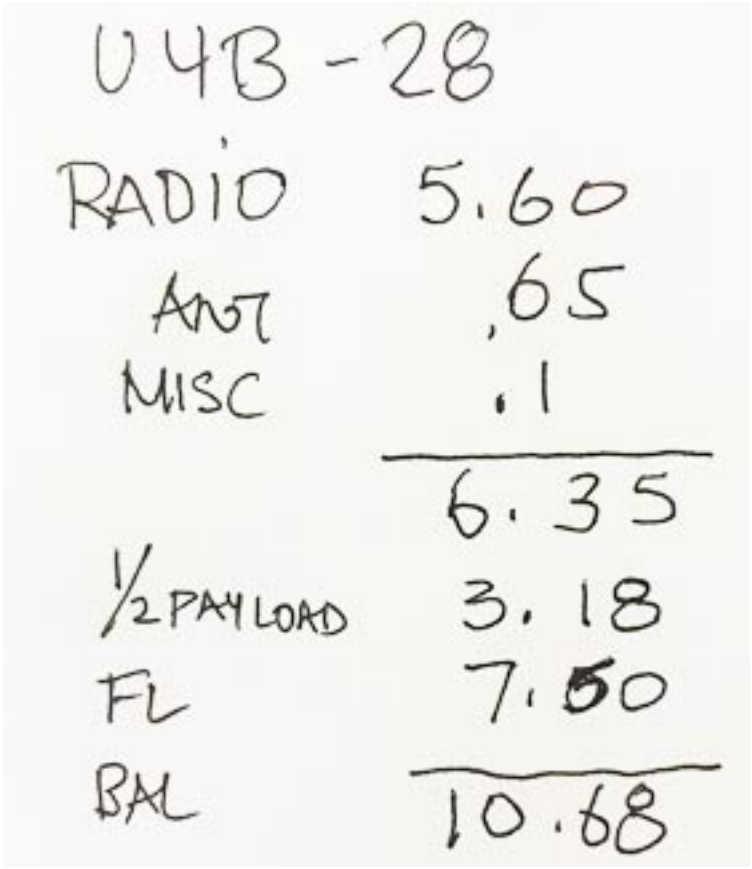
Prior to filling with a lifting gas, the balloons have to be evacuated of any air inside them. This is done with the vacuum side of the aquarium pump. A plastic aquarium tube is inserted into the neck of the balloon and secured with a rubber band. The balloon is laid as flat as possible and then the pump is turned on to remove the air in the balloon. The balloon will crinkle up and the vacuum tube is removed and the neck sealed with a spring clamp and a piece of flexible foam.

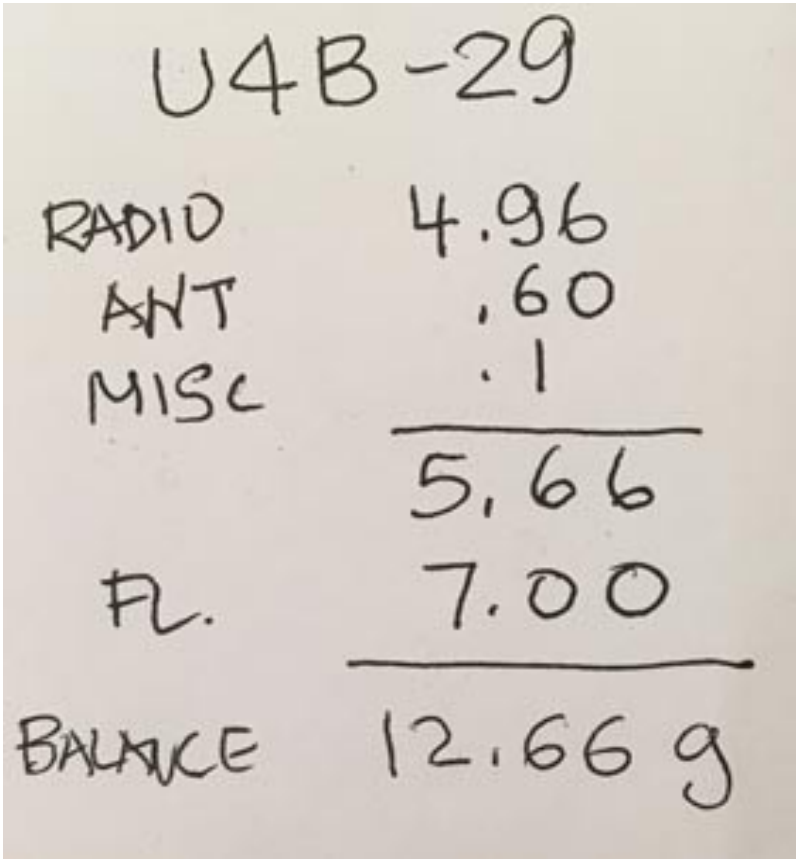
*Aquarium pump modified for vacuum and band or impulse sealer with timer for heat control*

*A white plastic tube is drilled in many places and inserted into the balloon to vacuum out the air*

*With the air removed the clear balloon looks like this*

About an hour before a launch, if the weather looks good, the balloons are filled or topped up with hydrogen and balanced to have the required amount of free lift. The balloon necks are sealed with an impulse sealer. The weight and balance calculations are done and written down on a piece of paper prior to filling with gas. This calculation takes the weight of the payload and divides that between the two balloons and adds the weight of free lift to be added to each balloon to compute the weight that must be attached to the balloon when filling. Before a flight, to accurately fill the balloon with gas, a weight is clipped on to the edge of the balloon that has been pre-weighted. The balloon is filled with lifting gas till it is buoyant and neither goes up or down when released in a windless space. For example, if only one balloon was being filled and the payload weighed 6 grams and the spreadsheet determined that 7 grams of free lift would work, the weight used to clip on the balloon would be 6+7 or 13 grams. The additional amount of gas added to the balloon that lifts the payload above neutral buoyancy is referred to as the free lift. This is usually around 7 grams per balloon with clear Chinese balloons. When calculating the balance with a two-balloon flight, the payload is equally shared between the two balloons but each balloon will still take 7 grams of free lift. With two balloons, the weight carried by each balloon would be ½ the payload or ½ * 6 = 3 grams.




*Weight and Balance notes: U4B-28 used 2 clear Chinese balloons and U4B-29 used a single 32” S.A.G. balloon*

And the balancing weight for each balloon would be 3 grams plus the free lift of 7 grams or 10 grams. A 10-gram balance weight would be clipped to each balloon and it would be filled with gas till the balloon was buoyant and then the balloon neck would be sealed. In summary to fill the balloon I make a clip-on weight that corresponds to the portion of payload + the free lift…. I usually use a dollar store black paper clamp, and add solder or washers to the clamp to get the required balance weight. The neck of the balloon is then sealed with an impulse or band sealer.

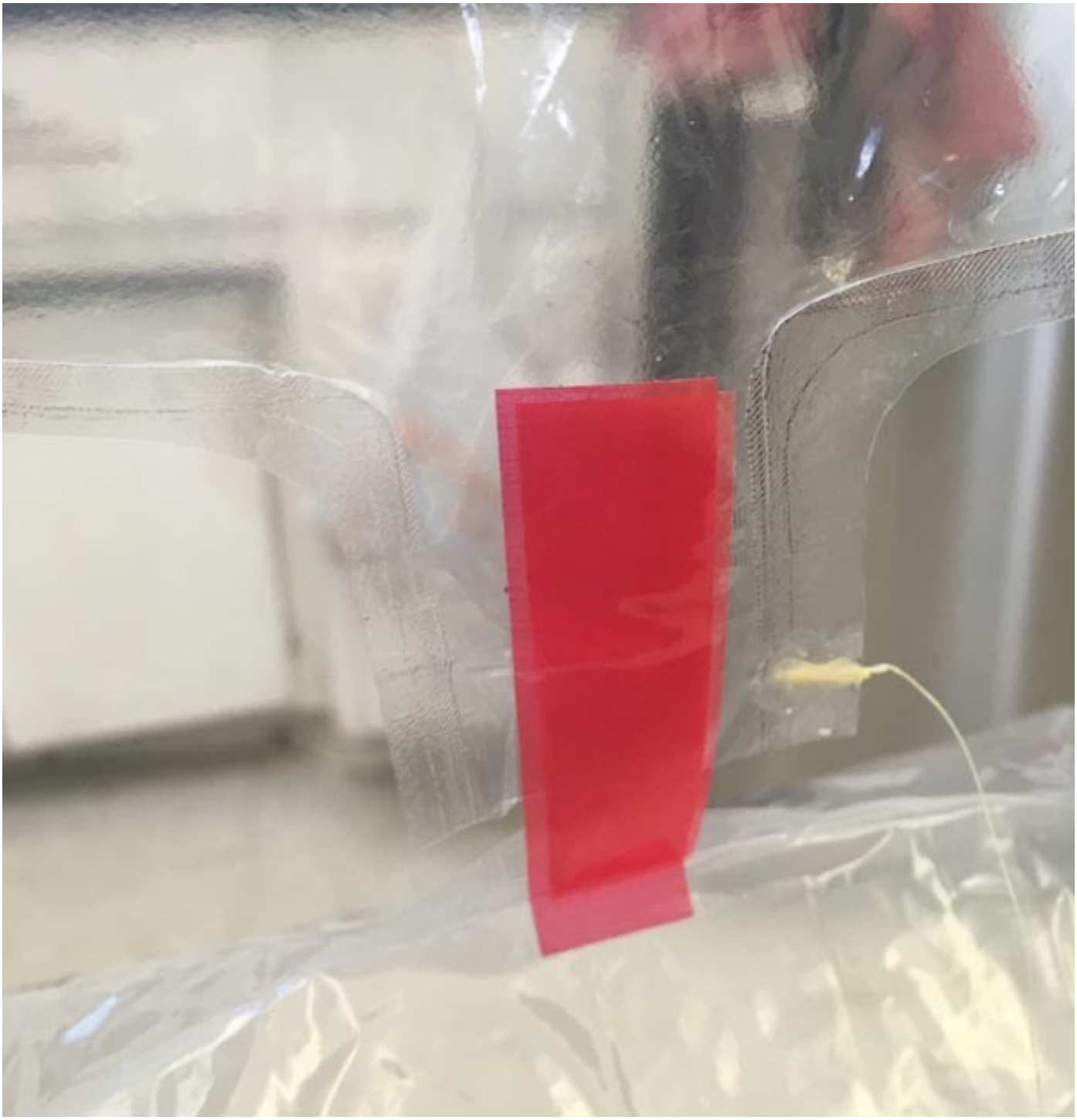
*Balloons just filled with hydrogen clipped with foam before sealing and held down with strategic heavy egg beaters*

*I usually seal the neck of the balloon 3 times, each time moving further away from the balloon center by creating a 3 mm gap between seals.*

*Balloon neck sealing detail*

It is a good idea to handle the balloons as little as possible, as every crease in the envelope could possibly leak the lifting gas a little faster. Using two clear Chinese balloons per flight, has been a preferred usage model. After sealing, weights are clipped onto the balloons to keep them from flying around. The lower balloon with the short line is held at floor level with a big weight while the upper balloon is fastened to the top of lower balloon with red Tyvek construction tape.


*Above Dyneema attachment through a hole in the plastic. Dyneema is tied glued and the hole is glued for strain relief*



*Two pieces of tape are uses one from each side of the neck of the upper balloon to the stub on the top side of the lower balloon. This Tyvek tape product holds building wrap on buildings through the winter in Canada, and is very robust, and seems good for the small job of holding balloons together. The upper balloon has a longer line attached to its neck (long enough as not to rub on the lower balloon when it is fully inflated). These lines, the long and the short, are tied together near the bottom of the lower balloon.*

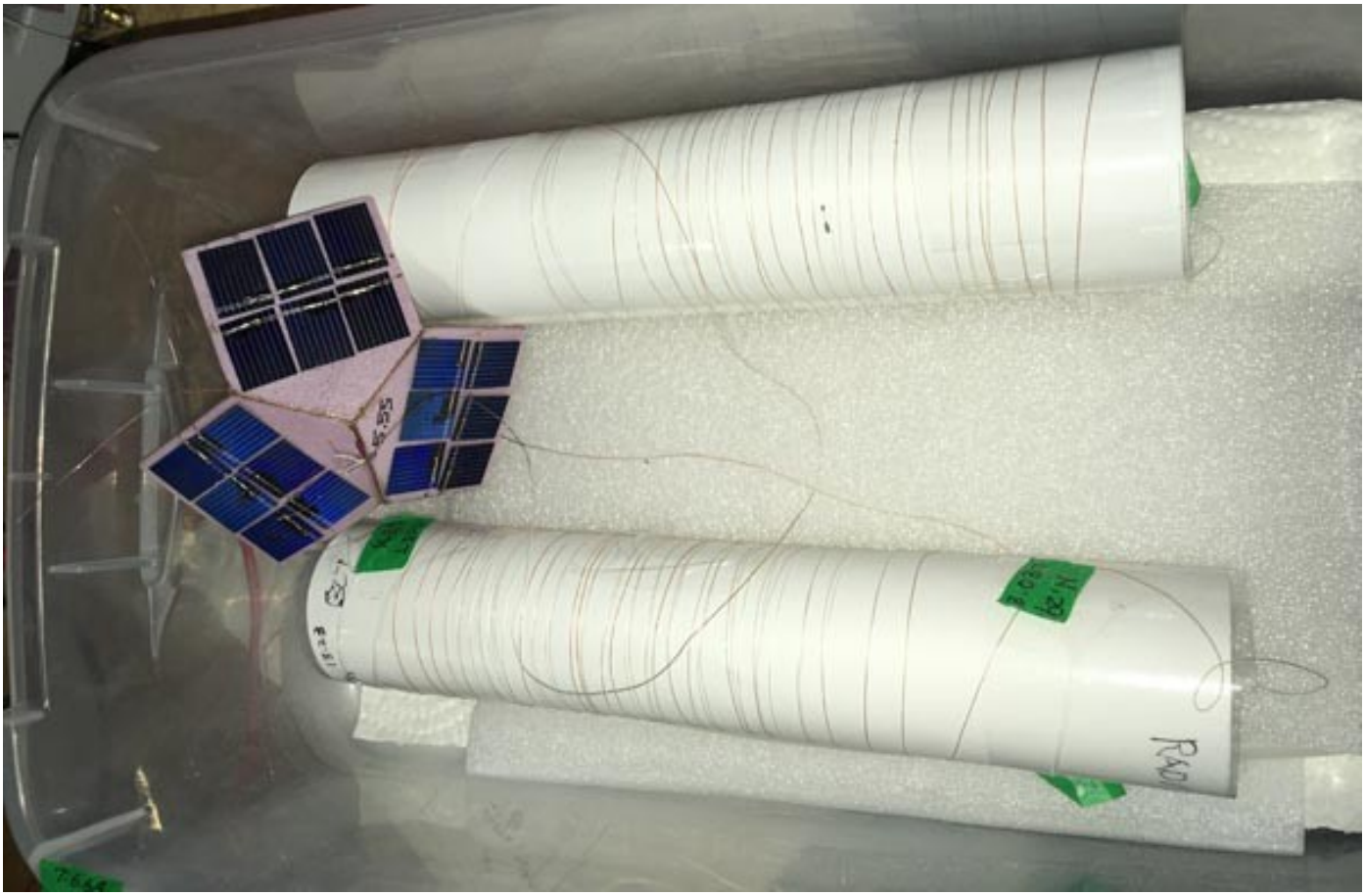
*Balloons stacked and taped ready for folding into the bed sheet*

*Balloons in the sheet with lines tied and extending out before all the spring clips are in place*

A folded bed sheet is laid on a table, the balloons are stacked on the sheet and then the rest of the sheet is folded over the balloons to make a bag. The edges of the sheets are fastened with spring clips allowing the balloon lines to exit the opening in the front of the sheet so the lines can be tied to the balloon antenna in the field without releasing the balloons or opening the sheet bag.

A telltale is a wind indicator constructed from a very thin plastic bag that is cut into a long 3/8” wide strip about 2 feet long.  This plastic strip is taped to the end of a stiff wire. The telltale is taken to the launch site and held up to determine the direction of the wind locally. It will respond to very light wind.

*A telltale stuck into the ground showing the prevailing wind has changed a bit*



*U4B in a shoe box tilted up after being checked in the sun to make sure it transmits. About 12 inches of antenna unrolled to give some ease of movement for the U4B when testing*

*Another shoebox detail ready to take out to launch*

The radio is kept in shoe box with foam and paper padding and contains both the upper and lower antenna elements on rolls that are loose at one end, and soldered to the radio at the other. Prior to leaving the house for a launch, I make sure the tracking program and Wspr radio is running so the first locally received spots will be recorded and forwarded to Wsprnet.

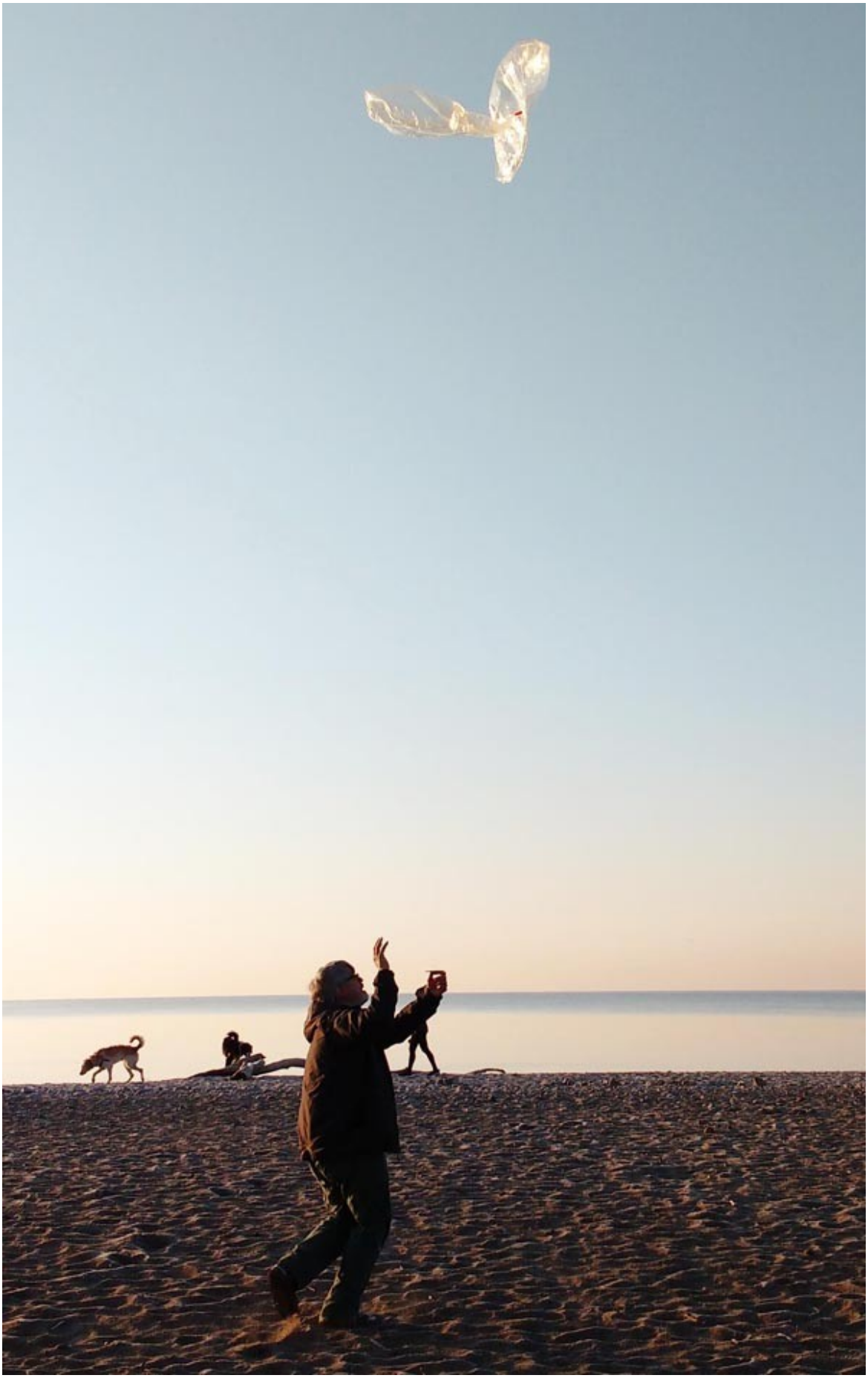
Four important things go to the launch: the bag of balloons, the shoe box with the radio, the telltale, and recently an old plastic tarp to save the lower antenna element from being tangled in the grass. Other things you may take in case things go wrong, would be a pair of tweezers, a sharp click knife, a dowel for unrolling the antennas and some scissors.

At the launch site one first determines the local wind direction with the telltale, and then moves up wind in the launch space so the maximum clear distance is in the downwind direction.

The balloon bag is laid on the ground with the balloon connection lines facing downwind and the shoebox is placed about 10 feet further downwind from the balloons. Downwind and at the shoebox, the tarp is laid flat on the ground. If the radio has a battery, the switch is now turned on so the Gps can acquire a position fix.

The U4B is kept in the shoe box and the upper dipole element is carefully unwound making sure there is lots of slack in the antenna wire and the radio does not get jerked in the process. It is smoother unrolling the antenna element from the paper roll, if there is a wooden dowel or plastic rod in the middle of the roll. The upper dipole element is tied to the lines protruding from the balloon bag and knotted about 3 times. The lower dipole element is then unrolled carefully and laid on the plastic tarp in a loose zig zag pattern in the downwind direction from the shoe box. The radio is carefully taken out of the shoe box and the empty shoe box is moved away, so it is not a tripping hazard. At this point it is a good idea to see that the solar cells are balanced and lying flat. A bend in the upper support wire can change the balance so the panels are now horizontal. If the solar panels are not flat, the sun will not evenly expose the solar panels in the morning and the evening and the power may drop out and miss transmissions.

An assistant removes the clips, and takes the balloons out of the balloon sheet.  They hold the balloons over their head at the attachment point where the Dyneema is fixed to the lower balloon. At this point, usually the balloons are blowing sideways in any light wind, so one waits for the balloons to be pointing straight upwards or when the wind is having a lull before the assistant lets go of the balloons. It is a bit trickier launching by yourself, holding the balloons in one hand, and the radio line in the other. If self-launching, immediately after releasing the balloons your free hand has to guide the upper antenna line so it does not catch on anything and will pull straight up on the radio as the balloons lift up. With two people, the balloon holder takes a picture after balloon release, while the other person has the radio held in one hand and the other hand holds the upper antenna wire above the radio to make sure it does not get tangled. Usually the balloons fly downwind toward the radio and lift the radio out of one's hand, as the balloons are overhead. Sometimes it does not work that nicely in a strong breeze, and the person holding the radio has to run to keep directly under the balloons till the balloons are finally are high enough to lift the radio up and away. The person holding the radio has to use caution to stay away from the lower antenna element on the ground and attempt to keep the balloons directly overhead so that they lift off vertically. If the wind is too strong, and the balloons are not overhead, if the radio is released, the balloons can pull the radio downwind. The radio might then swing down and hit the ground, being dragged along, or get the antenna tangled, or damage the solar cells killing the flight. It is best to try and keep the balloons overhead before releasing the radio.



*Dogs are a constant worry in a beach launch*

There has been limited testing on the S.A.G balloon as to how long it will stay afloat. Below are some notes.

A piece of ½” emt electrical conduit was formed to provide an interior dimension of 32” high and 32” wide to measure the size of the balloon as it is being stretched.

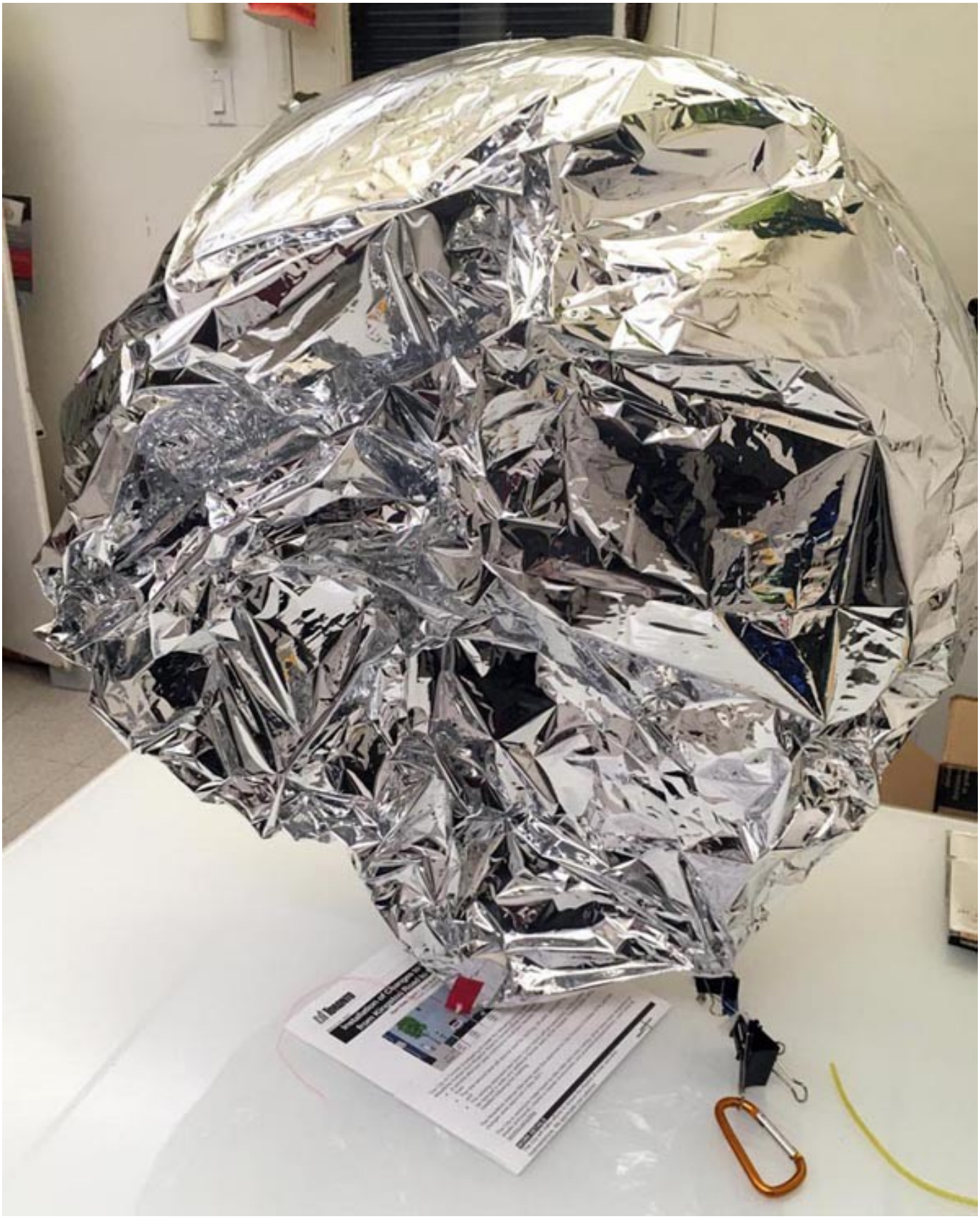
*As the balloons are inflating with 51% humidity and .25psi pressure*

*At over 60 percent humidity and .27psi  the balloon has reached its design dimensions of 32” and a few wrinkles are visible on the seams but for conservative stretching the pressure was stopped at this volume.*

*The balloon pressure was reduced to .2psi and the door opened to flush out the humid air … this pressure was maintained over- night.*

*The next day the pressure was reduced to .09psi and the dimension stayed almost the same (unlike the clear Chinese balloons )*

*The balloon on the left was evacuated for storage and the balloon on the right was open to the atmosphere and held its shape remarkably well.*



*The S.A.G balloon was filled with the 7 grams of free lift plus the weight of the payload and looks pretty sad with such low pressure inside the envelope.*

*Prior to launch the ugly looking balloon is held as high as possible.*

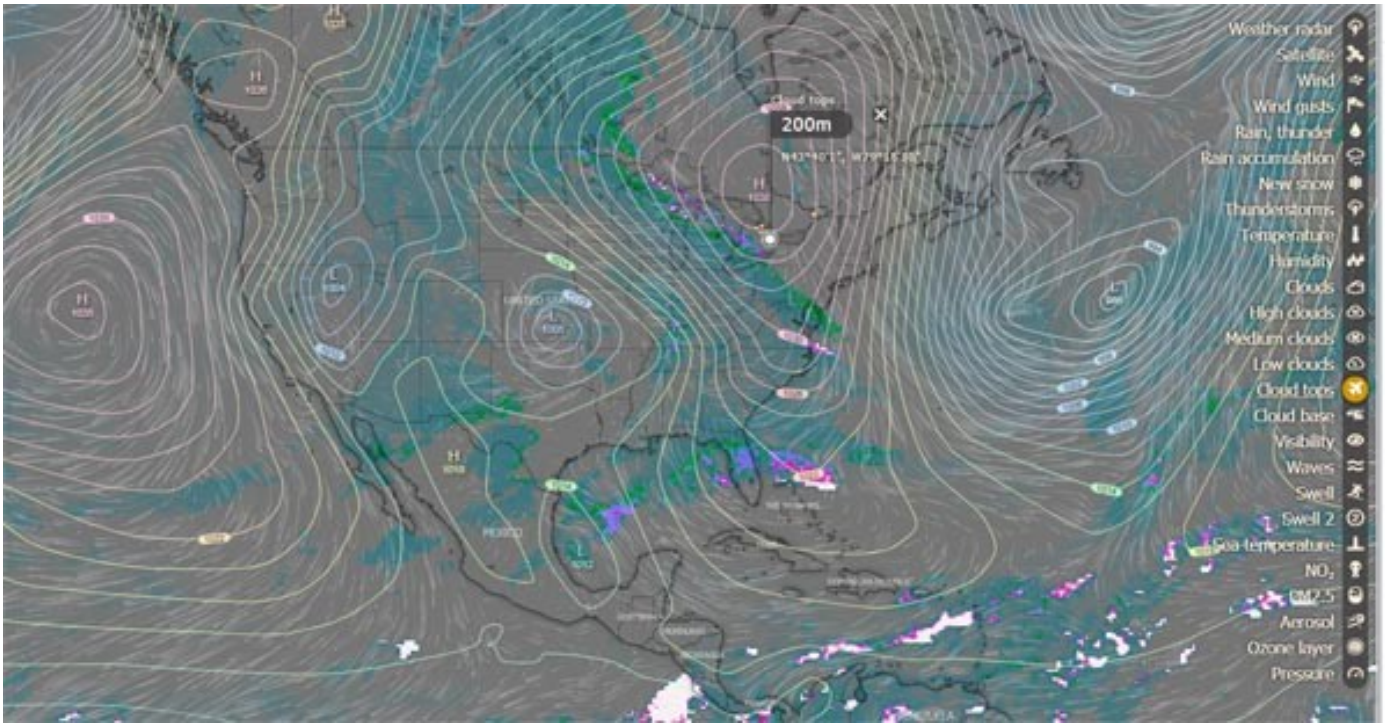
*Crumply looking balloon is lifting the payload and will eventually reach 14km although this looks unlikely from the picture.*

## High clouds

Clouds are the enemy of super pressure or floater balloons. In the winter, high clouds are not a serious problem for balloons in the northern hemisphere. The safest months for balloon flights, are months that have an “R” in their name. In these cool months, high clouds do not form and the highest clouds are mostly below the float level or below 10000 meters. In the summer however with a lot of heat generated by increased solar energy, the clouds develop to very high altitudes. Although the ambient temperature at 11km is often below -50c, if a balloon floats though a cloud, it can pick up ice crystals or super cooled water that can attach to the surface, and weigh the balloon down. Once the balloon’s free lift of (usually between 4 and 15 grams) is exceeded by the weight of ice crystals or water, the balloon starts descending. Here the excess lift from the lifting gas has been exceeded by the increased weight of water or ice. This condition is often referred to as icing. When the balloon is experiencing icing, it descends pretty rapidly until an altitude where the air temperature is above freezing. In warm air, the ice can melt off, and the balloon and payload can become lighter and can rise again. If this above freezing altitude happens to be during a rain storm, sometimes the weight of the rain can still exceed the free lift and the balloon will keep descending to the ground. On rare occasions when this situation has occurred, the balloon was able to eventually dry enough to lift off the ground and fly away. Usually hitting the ground is very treacherous, the antenna can get snagged in a tree or the fragile solar panels could be bumped then crack and fail. In some flights at night, when the payload was carrying a battery, and the temperature was too cold for the lipo battery to function, because the battery chemistry had frozen. The balloon then iced up and started descending. There was no solar or battery power to run the radio till below the freezing level at which time, the lipo battery thawed out and started powering the transmitter. On the receiving side, one saw by the sudden appearance of the balloon telemetry, in the dark, indicating that the balloon was at a lower altitude and descending. Sometimes in the summer, the balloon would slow stop and then continue to rise again as the ice melted away and it became lighter. And sometimes, it would not rise again but land in the sea, a very difficult place to make a recovery from. It is a sad moment receiving an unexpected balloon telemetry in the middle of the night indicating that the lovely balloon previously safely crossing the Atlantic at 12km has lost 9000 meters of altitude and is heading for a certain death.

## Windy.com

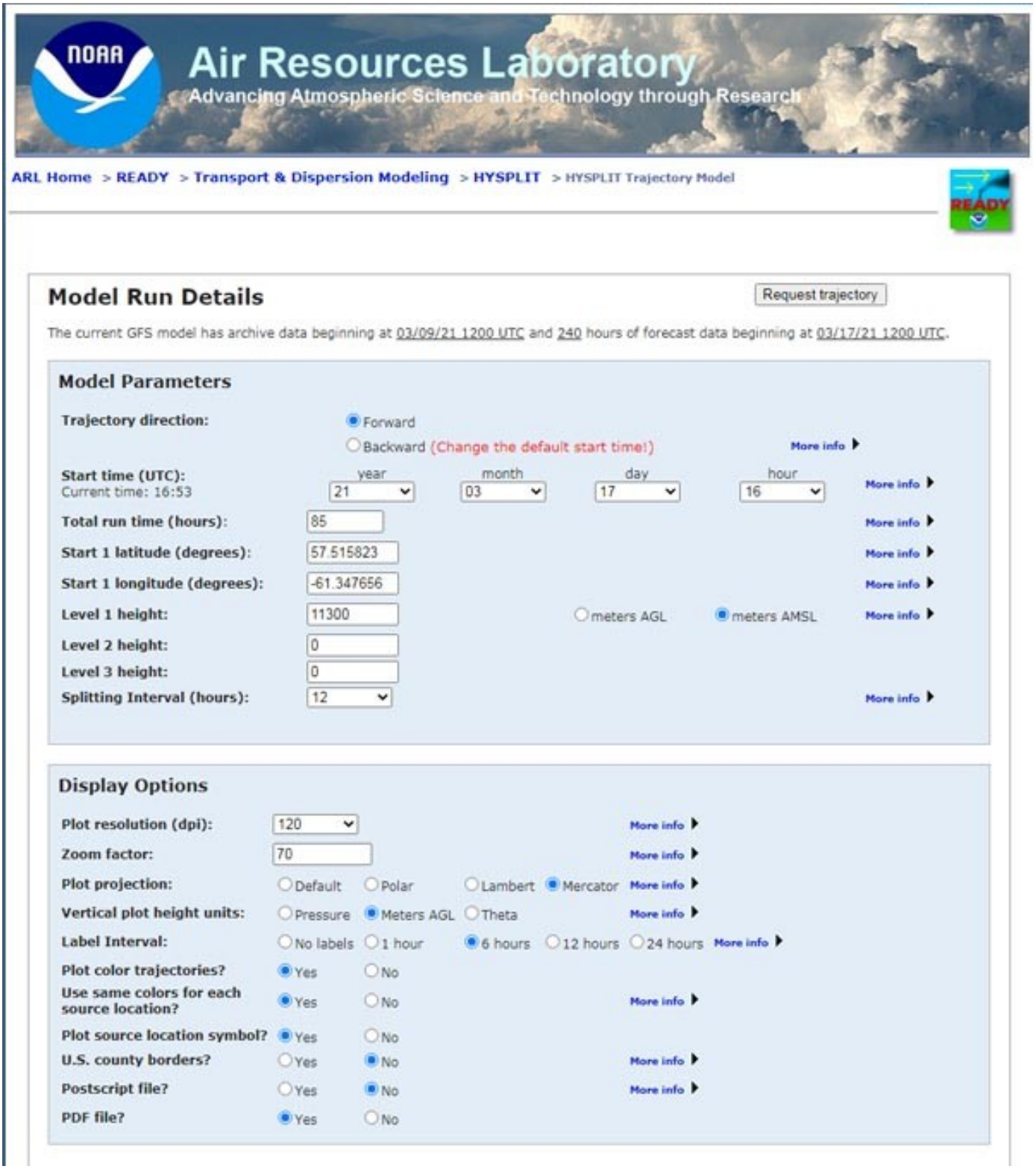
Windy.com is weather application that is a very valuable resource for setting up and watching balloon flight. It is a web based customizable weather map that can show one the location of high clouds tops, the wind currents at altitude, and forecast the winds for the day of the launch. Windy allows one to change the colours of the watched parameters to make problems stand out. Clouds are a hazard with floater balloons and Windy expands to show maps of a number of cloud statistics in a timely manner. Of particular interest is Cloud tops, that show high clouds, a hazard in the balloon’s path. One can change the colours of the display of cloud tops to display differently with altitude. It is an advantage to make clouds below 10000 meters invisible and only display clouds in a bright colour at and above the float level of your balloon.



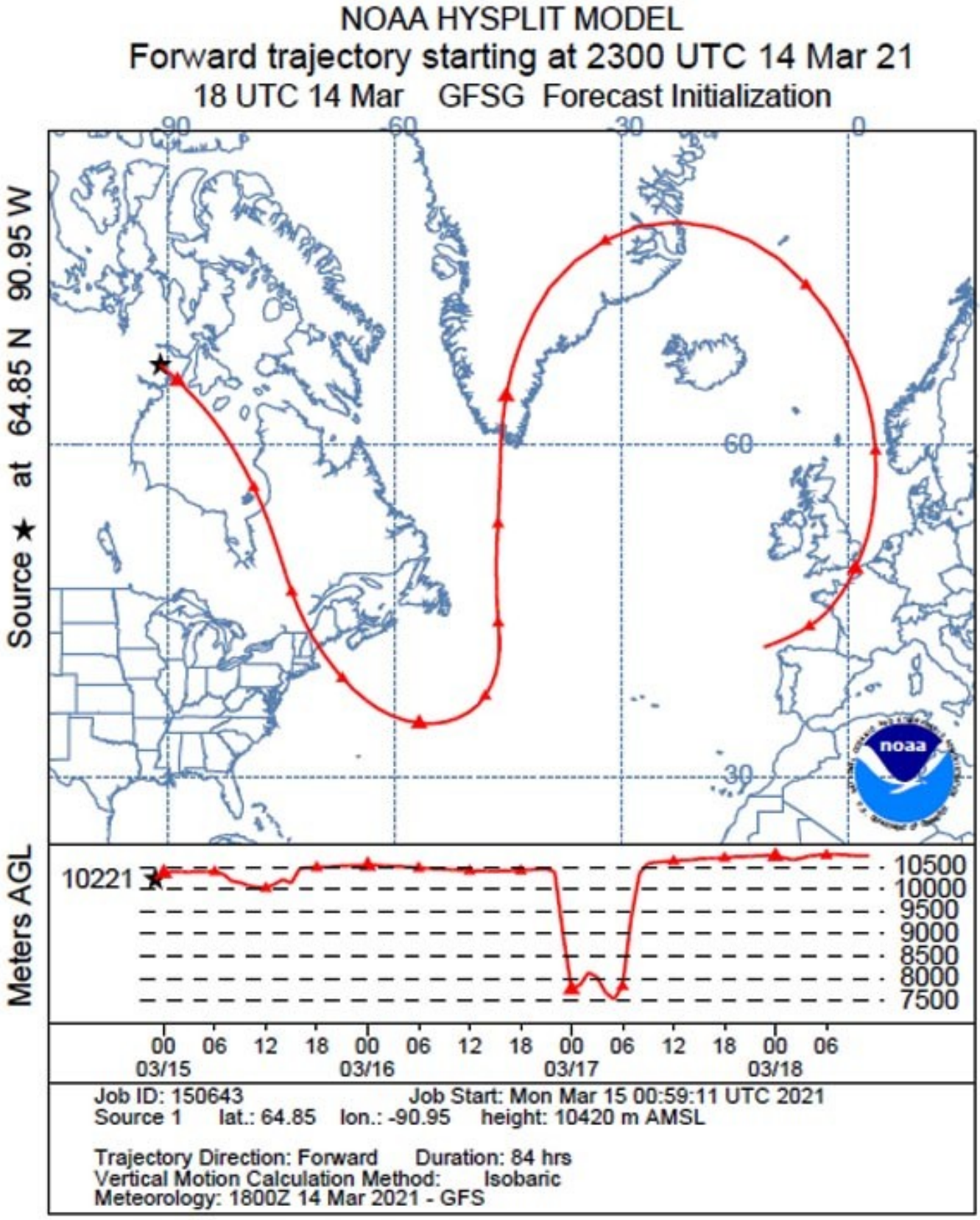

One can see at a glance in the above image, that there is clear sailing across the USA except for a few spots off the coast of Florida and a little bit of high clouds off the coast of Virginia. Recently by right clicking on the map at the balloon's location, Windy will reveal a window with a sounding option. The sounding will show the pressure and temperature at the reported altitude of your balloon which is very handy to determine the volume of the balloon. There is a draggable indicator that one can put in the balloon's path to get a good idea of the wind speed. Windy is a huge free resource with the additional benefit that one can move the time on the forecast bar at the bottom of the page and see how the clouds and wind should change in an approximate future forecast.

## Forecasting the balloons path using Noaa

Noaa (The National Oceanic and Atmospheric Administration) and its Air Resources Laboratory has an online forecasting tool called Hysplit that allows one to enter the balloon's latitude, longitude, altitude over sea level and time. It will generate a map of the balloons projected path over the next 3 or 4 days. Hysplit is quite accurate, quite often predicting the upper atmospheric winds and when a balloon may return if it has disappeared over the north pole in the dark and is not transmitting its location. When the balloon is absent in the dark, one can do a forecast at the end of a previous forecast, and it has known to work predicting a balloon's return. https://www.ready.noaa.gov/hypubbin/trajsrc.pltrjtype=4




*Above is how I set up a Hysplit forecast. Set run time for 84 hrs. or so, enter Latitude and Longitude and altitude. Set meters AMSL set plot resolution to 90 or 120 set projection to Mercator (or polar if near the north pole) vertical plot to Meters AGL as above.*




*Above a flight projection forecast showing the serpentine nature of the jet stream this time.*

**Everyone should experiment and find their own balloon tricks. The above methods were the fruit of numerous mistakes. Don't be afraid to try something new.**

**Most importantly remember to have fun and be safe…. Dave VE3KCL**