Goal

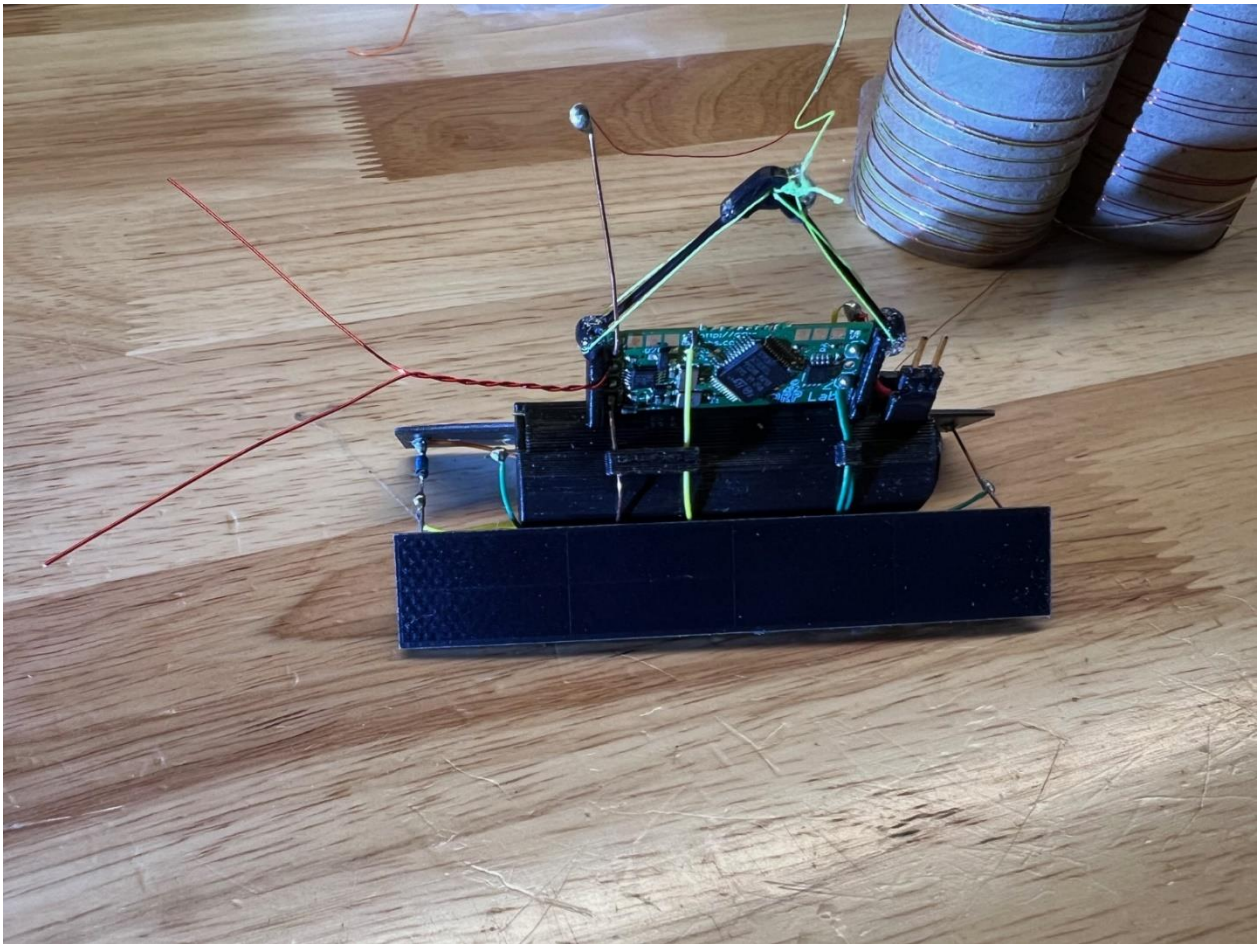
To design a Pico-Balloon that could operate 24 hours a day.

Design

After doing research on groups.io pico-ballooning and other mixed media, it became evident that to be successful, it would require a battery that could handle the cold temperatures encountered at high altitudes. After a lot of searching, I found and selected a Tadiran Lithium battery TLI-1550ES. Though not perfect, it provides the best operating temperature range, capacity and mass of any I found. Additionally, I would use a similar platform to what was used for ALP40-A, which circled the globe over 6 times in 74 days.

ALP40-G

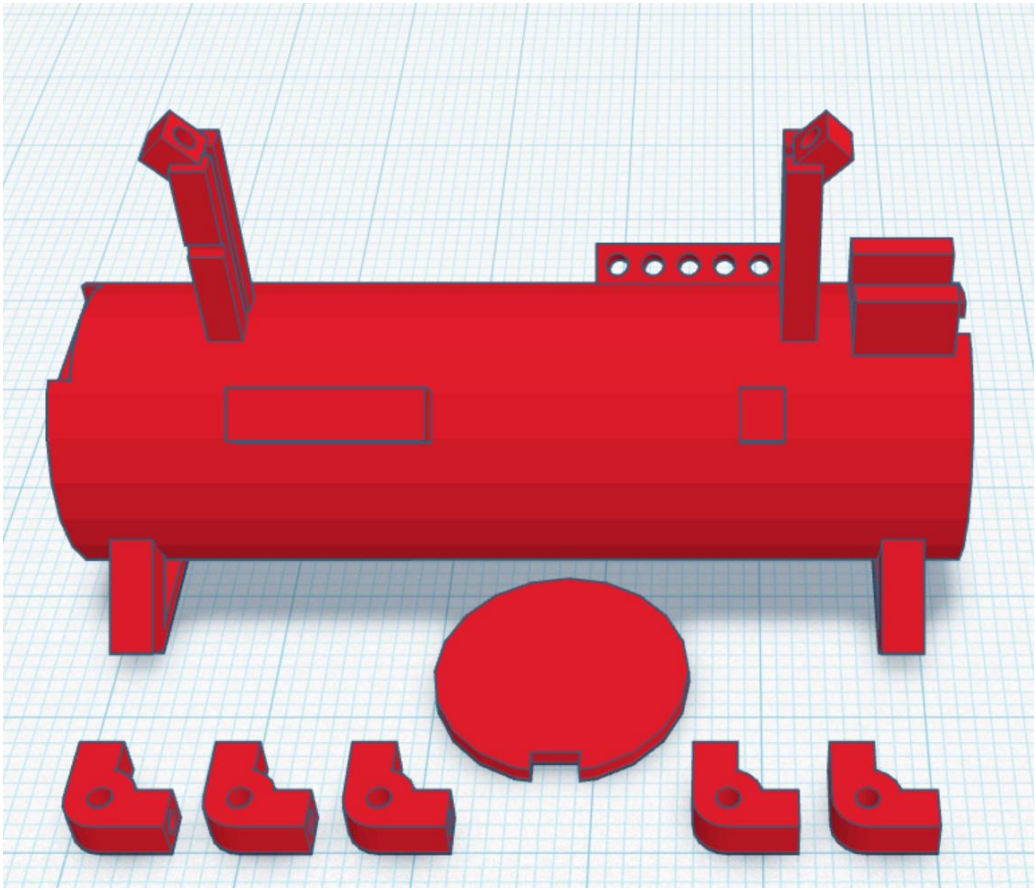
After the overnight success of ALP40-D, I used the same design, but with a sealed battery compartment; a battery compartment temperature sensor, Innovative Sensor Technology P10K.520.6W.B.010.D; and a higher power solar panel, Anysolar IXOLAR High Efficiency Solar MD SM141K08TF. The U4B software was modified to transmit alternate PCB temperature and battery compartment temperature. I used a standard GPS and HF (20 m) dipole antennas



A Chinese 60 (Name not diameter) balloon was used and stretched to 116”, the payload had a mass 38.4 grams, with a float of 6 grams and inflated with Hydrogen.

Construction

The process begins with building the frame for all the components. I use a Creality Ender 3v2 3D printer, but any model would work. It is printed using black ABS plastic, which has the desired properties. I use **TinkerCAD** to design the frame and export it as an "*. STL" file found **here**.

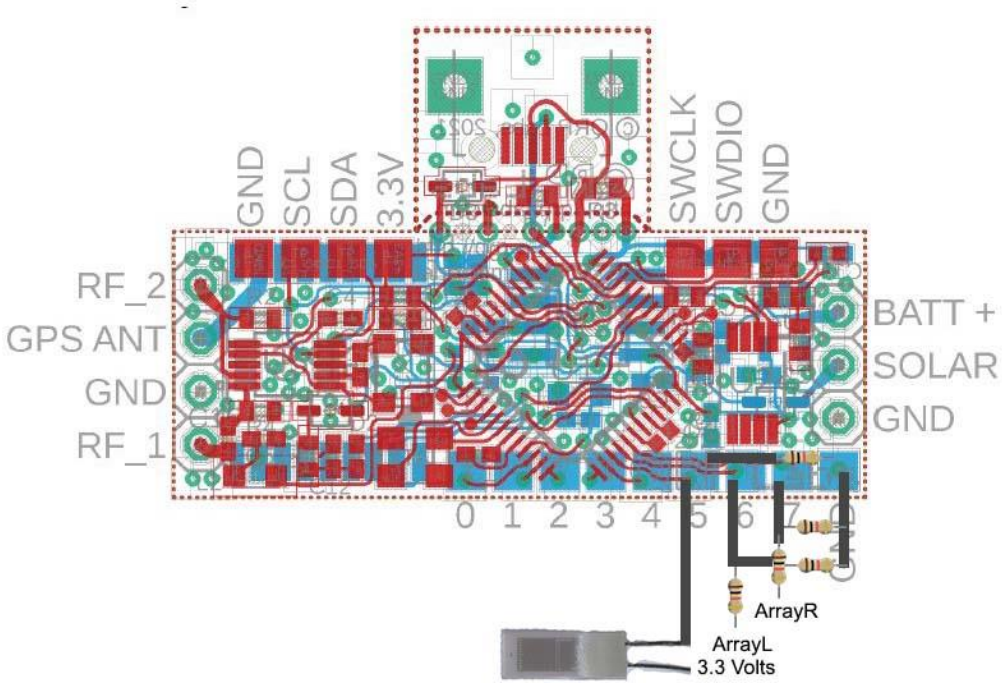


After printing, you get something that looks like this below.

Next, using 1mm **carbon fiber rod**, super glue and **Starbond Accelerator**, I complete frame construction, see below. A small **1mm drill bit** may be needed to open up the holes in the plastic for the CF rods to fit properly.

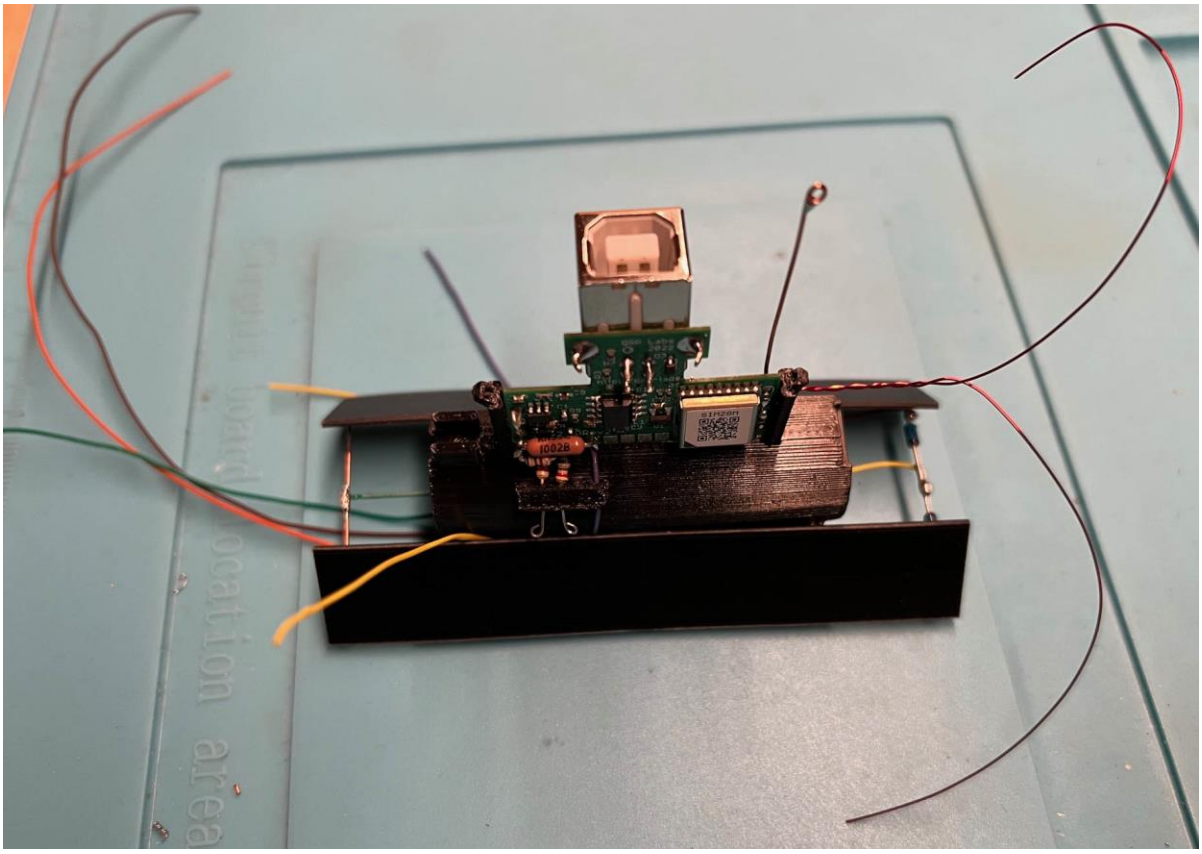
The solar panels will then need to be super glued to the frame and then wired in parallel with Schottky diodes in place on the positive side.

The U4B will then need to be wired with the additional resistor networks for the ADC. These provide the necessary signals to determine day or night and read the external temperature sensor.



For ALP40-G the external temperature sensor used ADC channel 4 instead of 5 as shown above, which will be reflected in the software. Since the external temperature sensor is 10K the other resistor in that network is also 10K. Finally, 6.8K resistors were used for the networks to read the solar panel voltages to determine day/night.

The battery is added, and the final wiring is completed, see below.



The finished product can be seen at the beginning of the article.

Software

Standard QRP Labs U4B BASIC programming was used. Program follows use at your own risk.

TALARC Balloon AP40-G Flight Code

Configuration

KB7HTA-14 – 20 Meters – CH 135 – WSPR 14.097180 – CW 14.022000 – Start Minute 08/00 – 1st & 3rd 0-6

Variables

Letter	Initial	Description
S	1000	This is the day/night set point used when array voltage before the diode is read
H	4000	This is the battery “High” set point in millivolts.

L	3800	This is the battery “Low” set point in millivolts.
V	3400	This is the battery “Very Low” set point in millivolts.
O	273	This holds the battery compartment temperature in Kelvin after the “BCT” subroutine is RUN
F	0	If this flag is true (1), then the next TELE sends the external temperature vs PCB temperature.
M	5000	Below this altitude in meters, send a CW report with latitude, longitude and battery voltage
Z	0	This variable holds the result of reading both solar panels before the diode and adding them together. Solar panels should not put out more than 5 Volts (>4.84 max spec for solar panel used). There is a 10K Ohm divider network, so the maximum should be no more than 2.5 Volts. Full scale 12- bit ADC reading would be 4096 representing 3.3 Volts, so 2.5 Volts would be 4096*2.5/3.3 = 3103 meaning full sunlight. When compared to the day/night set point, day or night can be determined.
A	?	Temporary Variable
B	?	Temporary Variable
C	?	Temporary Variable
D	?	Temporary Variable

```
LET HP = 0
LET S = 1000
LET H = 4000
LET L = 3800
LET V = 3400
LET O = 273
LET F = 0
LET M = 5000
GPS 300
RUN “QLOCK”
10 RUN “QND”
IF Z > S
   GPS 300
   RUN “QBCT”
   OUT 19 0
   SLEEP 10 7
   OUT 19 1
   TELE
   RUN “QCWD”
   GOTO 20                    */Not sure why, but this is needed to make the IF ELSE coding to work properly
ELSE
   GPS 300
   RUN “QBCT”
   OUT 19 0
   SLEEP 10 7
   OUT 19 1
   TELE
   RUN “QCWN”
20 ENDIF
```

```
RUN “QDWN
GOTO 10
END
~
```

QBCT – Determine If **B**attery **C**ompartment **T**emperature Needs to be Read and Substituted for U4B Temperature

```
IF F > 0
   RUN “BCT”
   LET TT = O
   LET F = 0
ELSE
   LET F = 1
ENDIF
~
```

BCT – Read and Convert the **B**attery **C**ompartment **T**emperature to Kelvin

```
LET A = INA 4
DELAY 1
LET A = INA 4
LET B = A * 806
LET C = 3300000 – B
LET D = C / ( B / 10000 )
LET O = ( D / 38 ) + ( D / 39 )
LET O = O / 2
~
```

QND – This program is run to determine if it is day or nighttime.

```
LET Z = INA 6
DELAY 500
LET Z = Z | INA 7
~
```

QCWD – This program is run during the day to determine, depending on battery voltage, whether to send a CW transmission or sleep for one/two 10-minute cycle(s) to recharge the batteries.

```
IF BT > H
LET HP = 1
CW 0 14022000 12 0 “CQ KB7HTA KB7HTA BALLOON #M6 #AT #BT”
CW 0 14022000 12 0 “CQ KB7HTA KB7HTA BALLOON  #LT #LN”
LET HP = 0
ELSE
OUT 19 0
SLEEP 10 8
OUT 19 1
```

```
ENDIF
IF BT < V
   OUT 19 0
   SLEEP 10 8
   OUT 19 1
ENDIF
~
```

QCWN – This program is run at night to determine, depending on battery voltage, whether to send a CW transmission or sleep for one/two 10-minute cycle(s) to conserve the batteries.

```
IF BT > L
OUT 19 0
SLEEP 10 8
OUT 19 1
CW 0 14022000 12 0 “CQ KB7HTA KB7HTA BALLOON #M6 #AT #BT”
CW 0 14022000 12 0 “CQ KB7HTA KB7HTA BALLOON #LT #LN”
ELSE
OUT 19 0
SLEEP 10 8
OUT 19 1
ENDIF
IF BT < V
   OUT 19 0
   SLEEP 10 8
   OUT 19 1
ENDIF
~
```

FLASH – This program is used during development to send a number of light flashes in variable A.

```
FOR X = 1 TO A
OUT 19 0
DELAY 1000
OUT 19 1
DELAY 1000
NEXT
~
```

QLOCK – This program determines if the balloon has a GPS lock. If there is a lock it turns off the LED, otherwise it flashes the LED 10 times and leaves it lit.

```
IF GL = 0
LET A = 10
RUN “FLASH”
OUT 19 1
ELSE
OUT 19 0
ENDIF
~
```

QDWN – This program determines if the balloon is possibly going down. It sends CW Latitude Longitude and battery voltage if the balloon goes below the value of variable M, which is usually 5000 meters or 16,000' (My choice).

```
IF AT < M
LET HP = 1
CW 0 146585000 12 0 "KB7HTA #LT #LN #LT #LN #BT"  */Transmits on Fox Hunt (T-Hunt) frequency
LET HP = 0
ENDIF
~
```

Payload Mass:	35.5 grams
Dipole Antenna Top:	1.9 grams
Dipole Antenna Bot:	1.0 grams
Total Payload:	38.4 grams
Float:	6.0 grams
Neck Weight:	44.4

Neck Weight Simulated with, tube, hose, yellow clip, black clip and 1" black toroid for 44.8 grams.