2020

SatTracker

JP
Freedom2000
01/11/2020

Sommaire

Objectif

Let's start by two video of a real ISS tracking in my home :)

One at 16x speed and one much longer but with explanations !

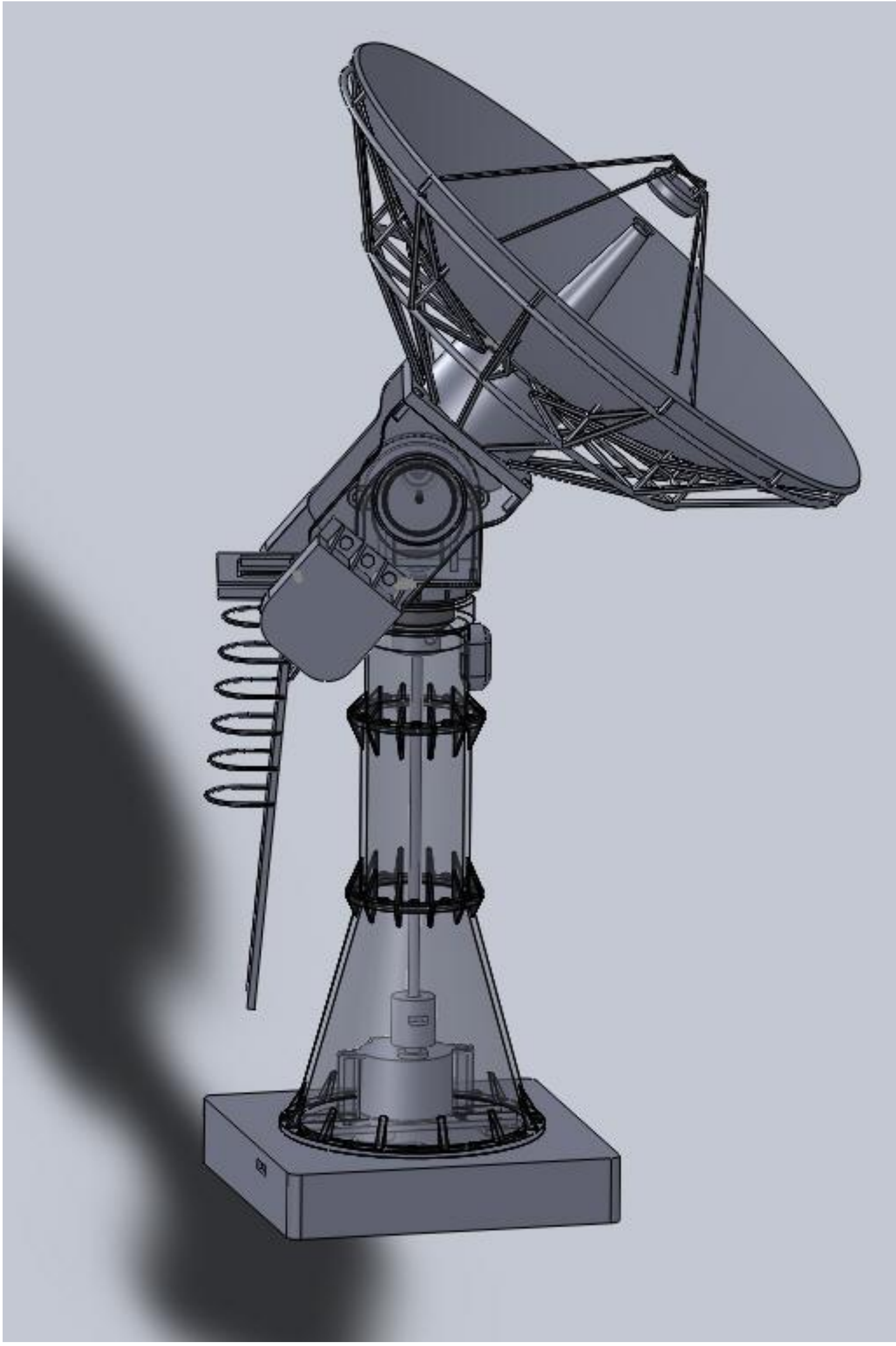
https://youtu.be/MYff_J85vZo

https://youtu.be/_7pX7NHbo6A

So here is a mockup of a ground station antenna, able to track any LEO sat you want.

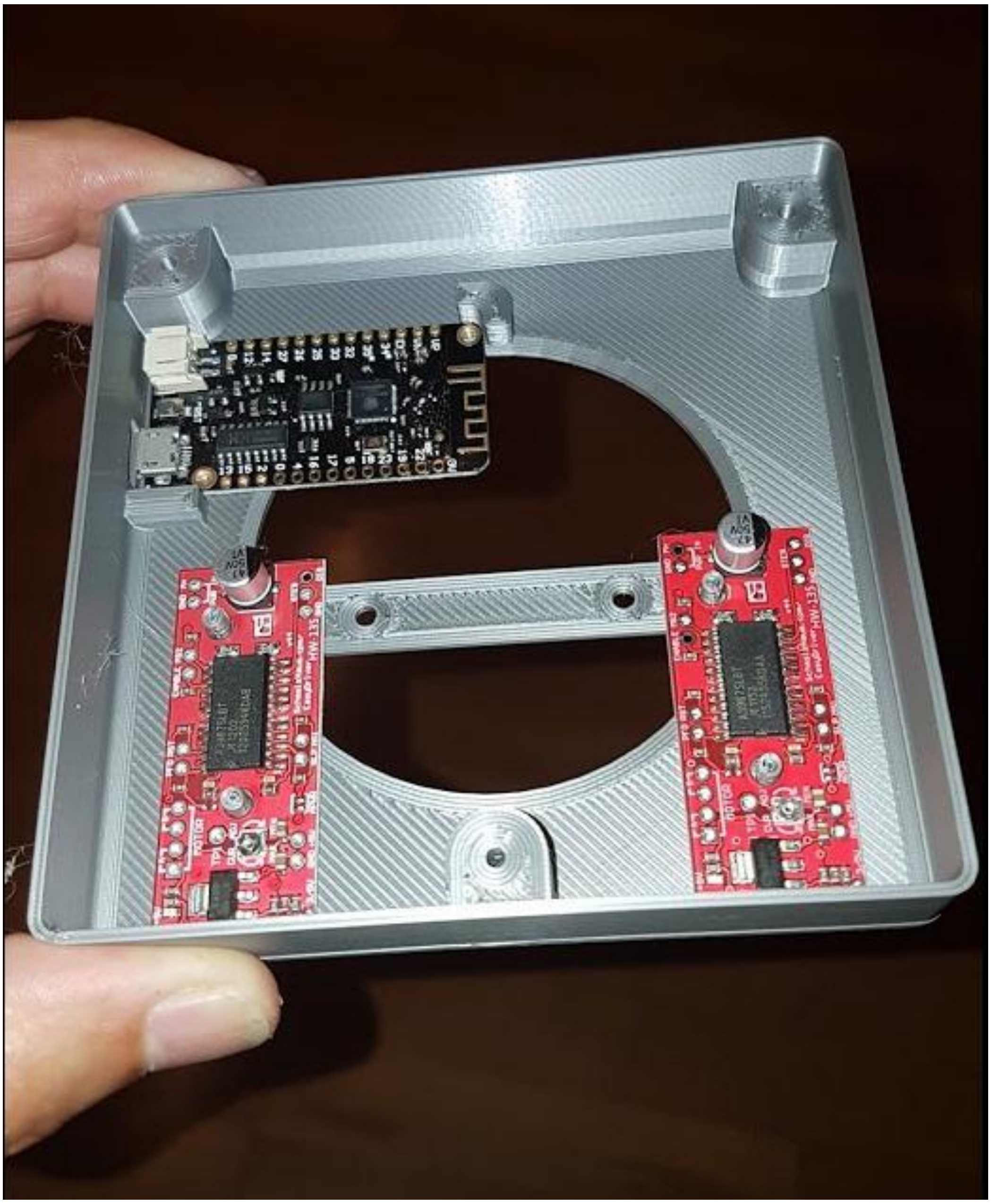
The antenna is 3D printed from a design I made starting with a 6 meter dish antenna picture.

The dish is now 20cm wide, has a real paraboloid shape and is moved by two stepper motors fully hidden into the pedestal of the antenna.



Two hall effect sensors and two magnets allow to setup the antenna horizontal and pointing to north at boot time. They are also hidden into the structure.

An ESP32 is also hidden in the basement and is the heart of the system. It computes the position of the satellites every 1ms and computes the azimuth and elevation angles from your antenna to the satellite.



An android App (Pro version only) allows to visualize the track and to send parameters to the antenna : which satellites to follow, the Two Lines Elements and the time.

https://www.b4x.com/android/forum/threads/iss-and-leo-satellites-tracker.123325/

The orbit propagator is embeded in the ESP32 and uses the excellent SGP4 library ported by hopperpop ! https://github.com/Hopperpop/Sgp4-Library

the firmware was directly inspired by Alex Chang project : (Thanls Alex for sharing)
https://create.arduino.cc/projecthub/alex_chang/satellite-tracker-13a9aa

A simple version is available for free download.
For the Pro version and the companion Android App please contact me.

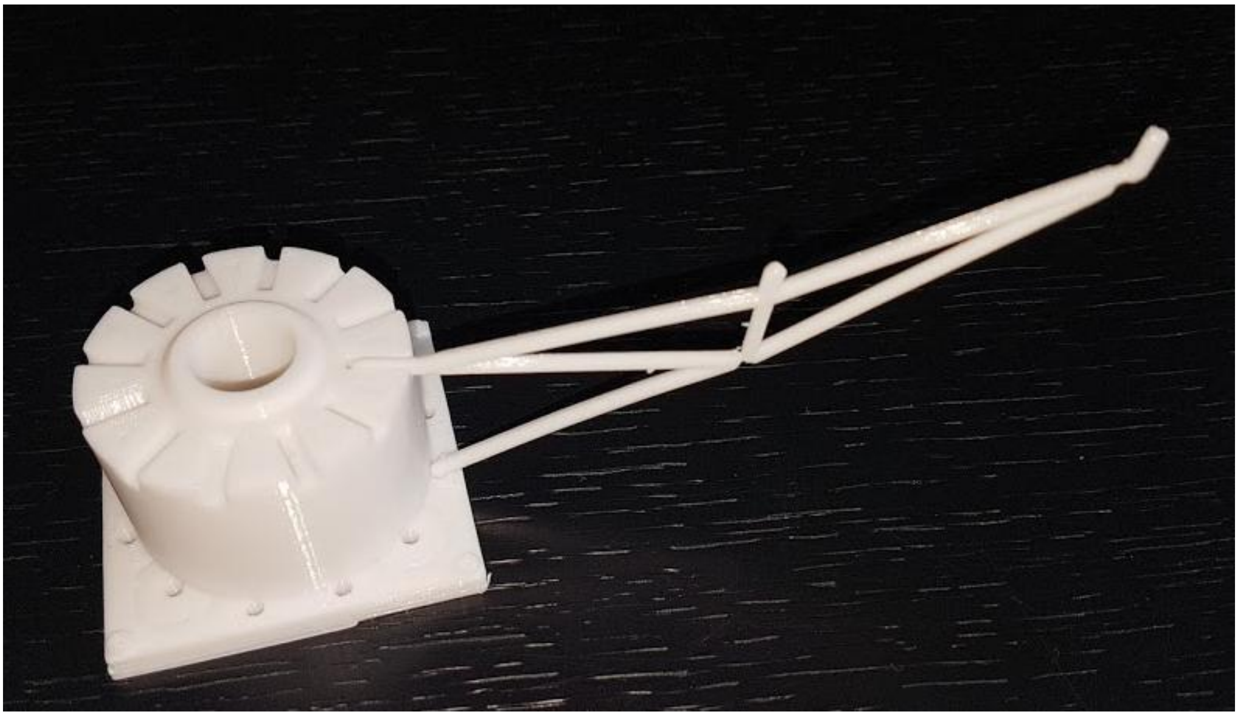
How to do it

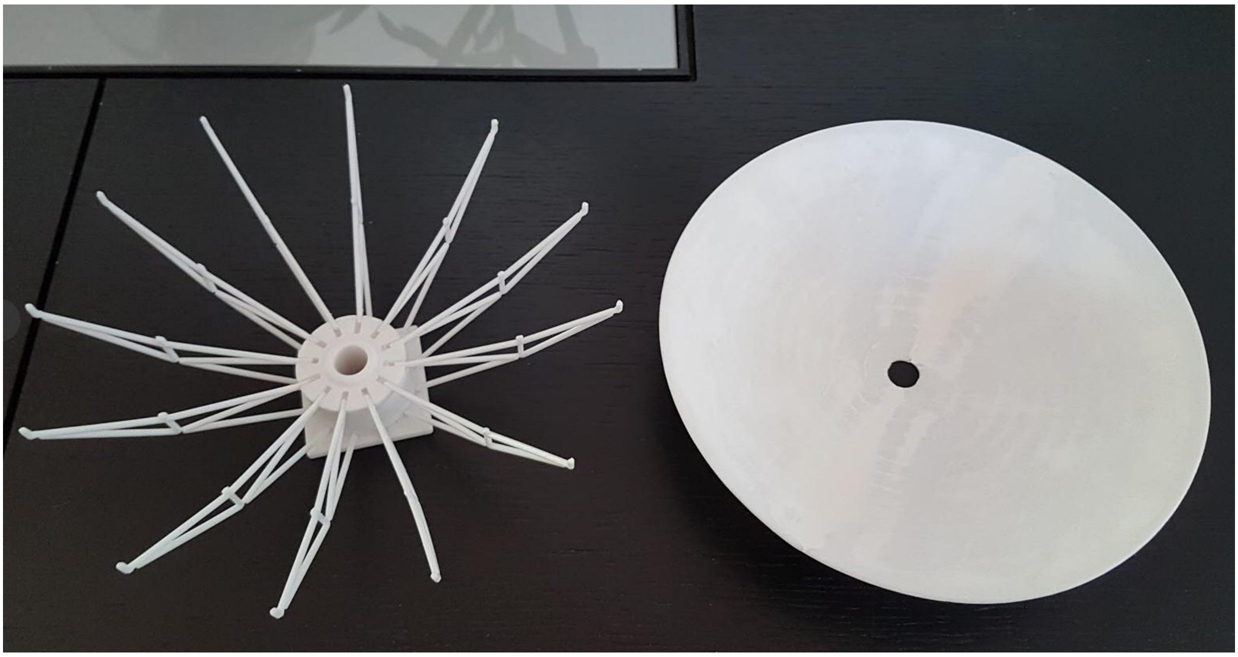
Everything is printed with PLA, no support, 0.2mm width.

Print the dish in two halves (brim may help !).

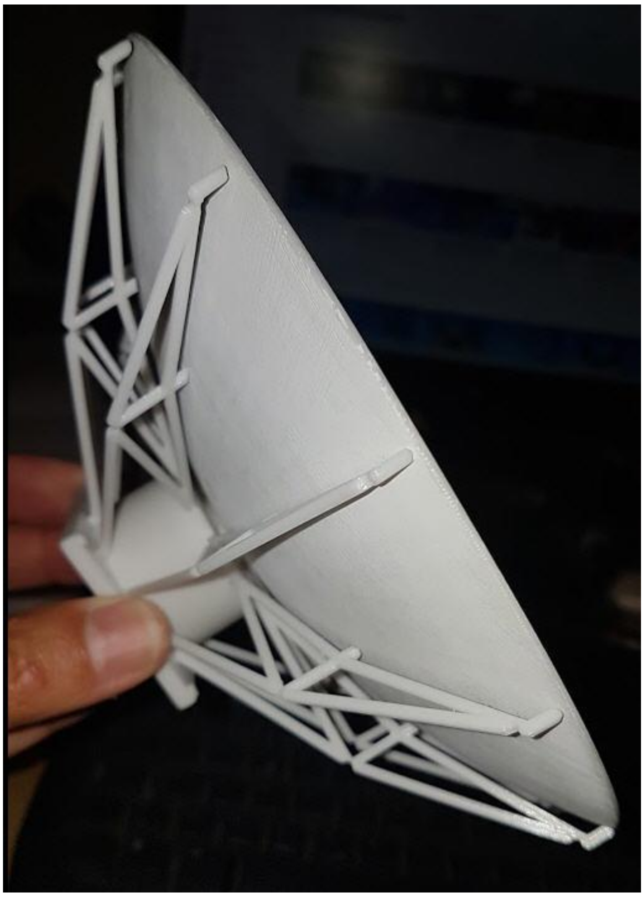
Then glue both parts with epoxy glue. Sand, fill, re sand and paint it.

print the support and twelve elements of the "umbrella"





Use the dish to be sure that the arms are properly aligned when gluing. Try to glue the arms two by two diametrically positioned.



Glue the dish in place and center it into its base

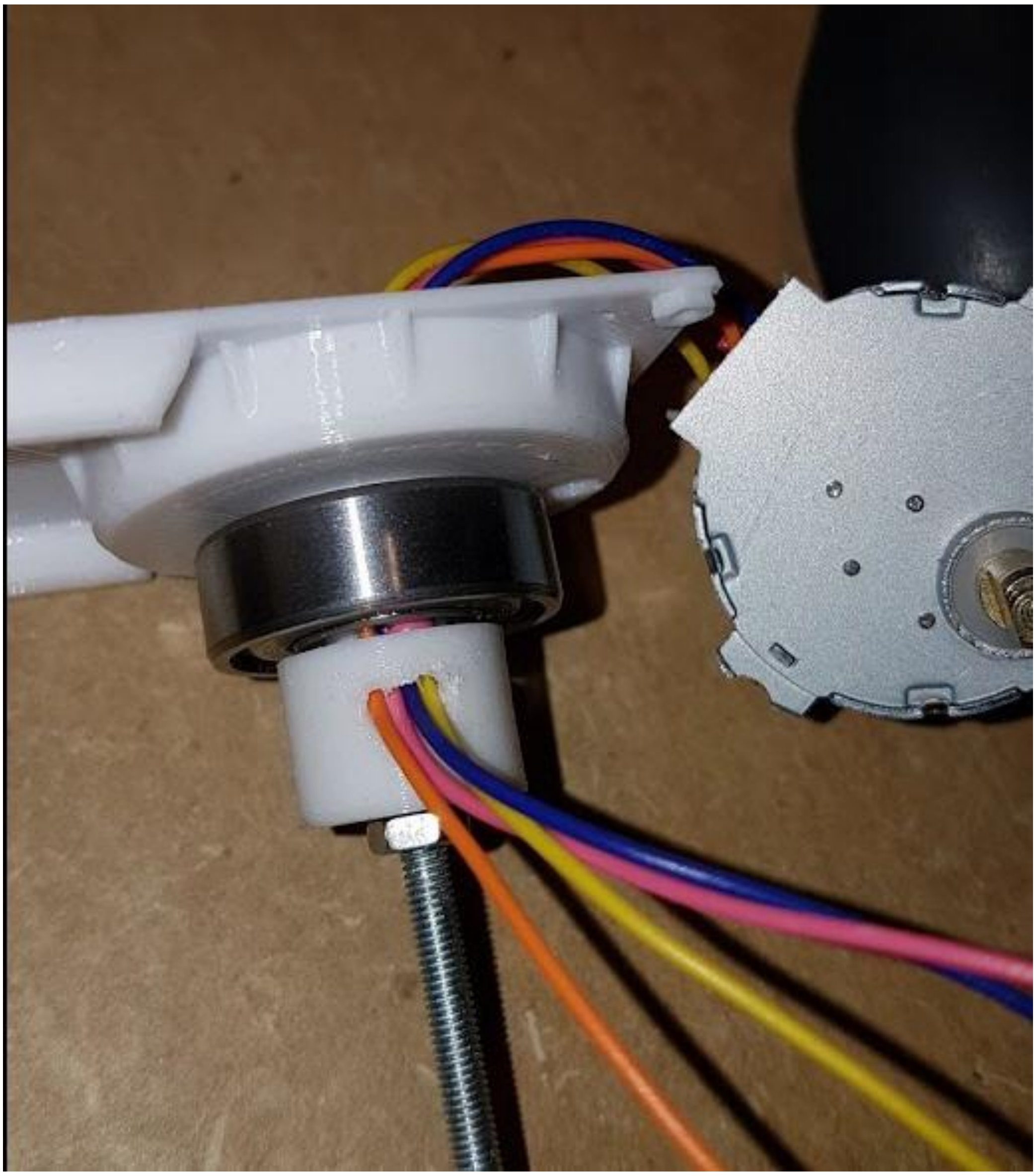
add the horn and its supports (**beware they are fragile**)

add also the two rings into the slots to finish the dish.

print the three pieces of the foot but don't glue them together now. It will be easier to glue them when the whole antenna will be finished !

Then print the azimuth shaft parts and use a 3mm leadscrew as the shaft. see stl template for the length.

The motors wires are slided into the roller ball bearing axis, so that they won't tangle when the antenna rotates.



As you can see the “ears” of the elevation motor are cut. The motor will be hot glued in place on its supports.

Beware also that the motor is converted to a bipolar one (four wires instead of 5). Follow these instructions for this modification: https://www.thingiverse.com/thing:3746391

the dish weights around 120 g. This must be balanced by counterweights on the other side of the antenna.

Note that the counterweight is half the weight of the antenna dish and made with lead molten into a metal shape of the plastic counterweight. This is absolutely needed to keep the antenna balanced, as the dish weights 120g... So 60g of lead on each side, thus a total of 240g. Just small enough for the motor to be able to move all this !

When everything in place, glue with epoxy to seal the counterweights.

Then add pieces of PLA filament to help you center the counterweights on the dish and glue all this in place.

don't forget to add a 2mm magnet into one of the counterweights. It will be used to calibrate the elevation motor. It mut be glue into the side which does NOT have the shape of the motor shaft.

Do the same in the foot of the antenna for the azimuth axis calibration.

The small flat side of the hall sensor must be parallel to the magnet. On the following picture the hall sensor must be bent to the bottom of the picture for the smallest face to be horizontal facing the top of the antenna.

The two hall sensors and magnets must be put placed in way that the hall switch acts (closes) when the magnet is close to the sensor. Beware that the magnet has a “side” (north south). The hall sensor switch will only trigger with the right polarity… try it before gluing the magnets ! If this does not work, then simply rotates the magnet !

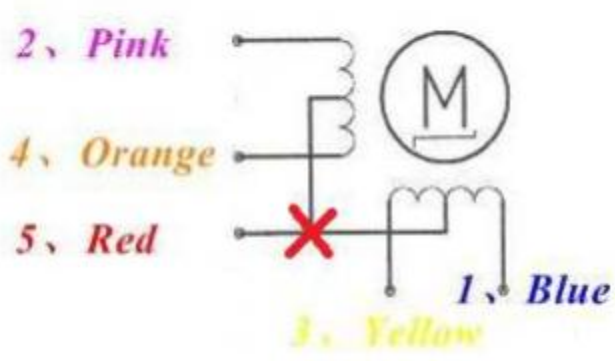
Electronics

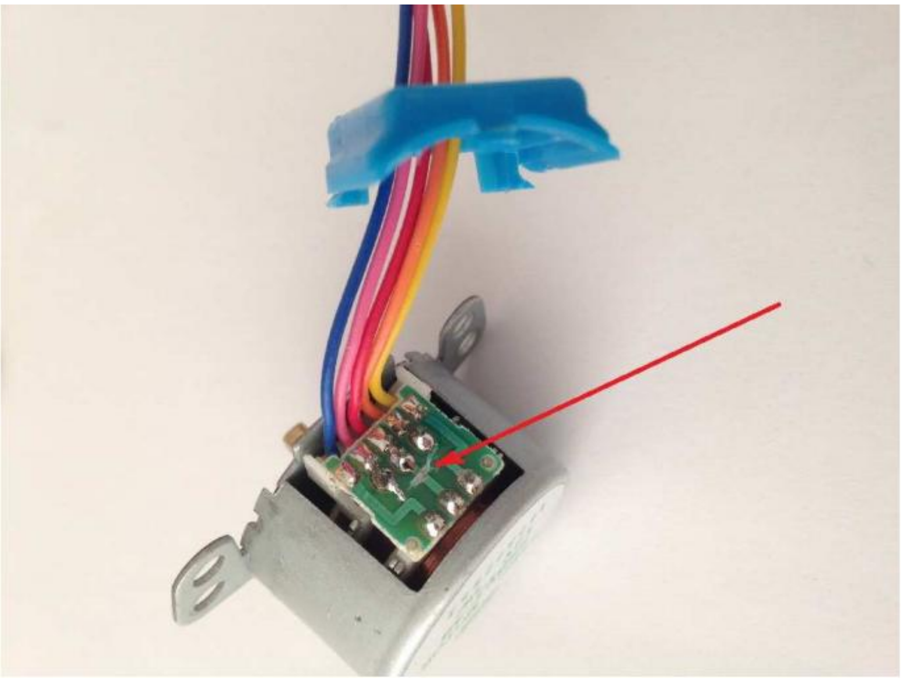
Motors :

We are using two tiny and cheap steppers motors reference 28BYJ-48 (5V model)

As already mentioned the motors have been modified to switch it to bipolar (to increase torque). Modification is explained here : **https://www.thingiverse.com/thing:3746391**

It is easy just a copper track to cut.





You can then cut the red wire as well.

Drivers

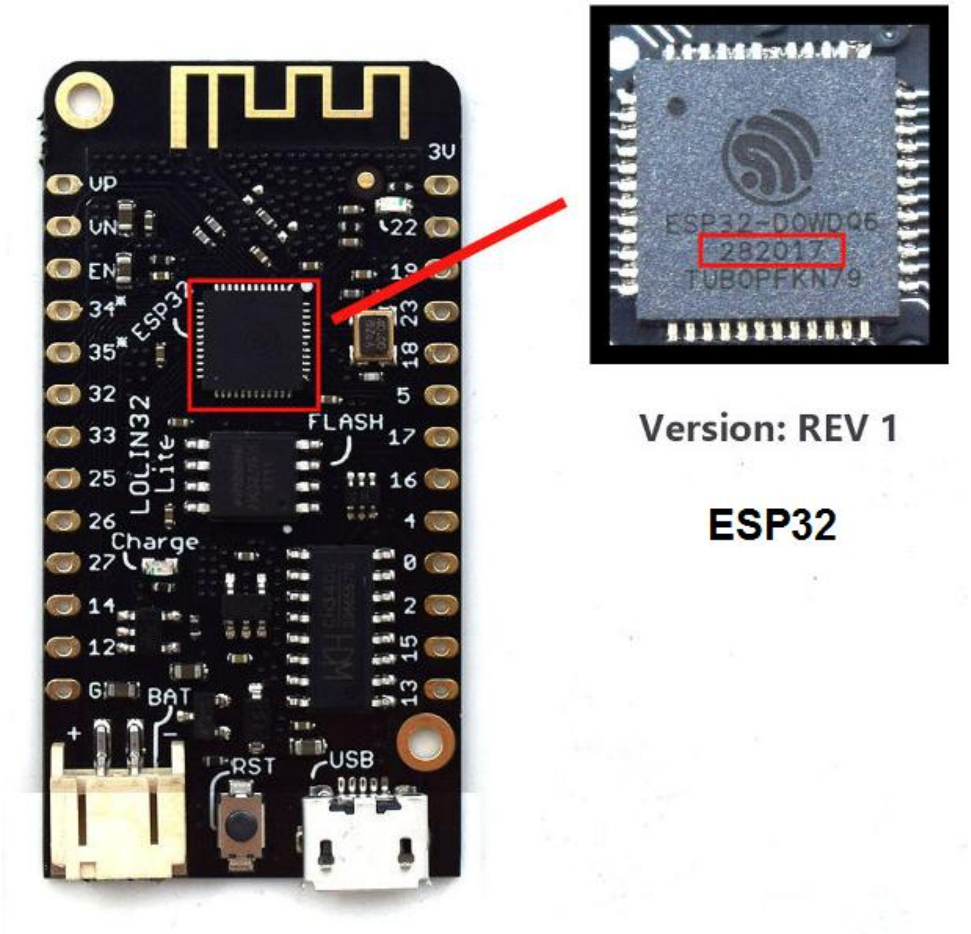
I do use two easysteppers drivers. They are cheap and can be used directly out of the box.

Detailed information here : https://www.schmalzhaus.com/EasyDriver/

Microcontroller

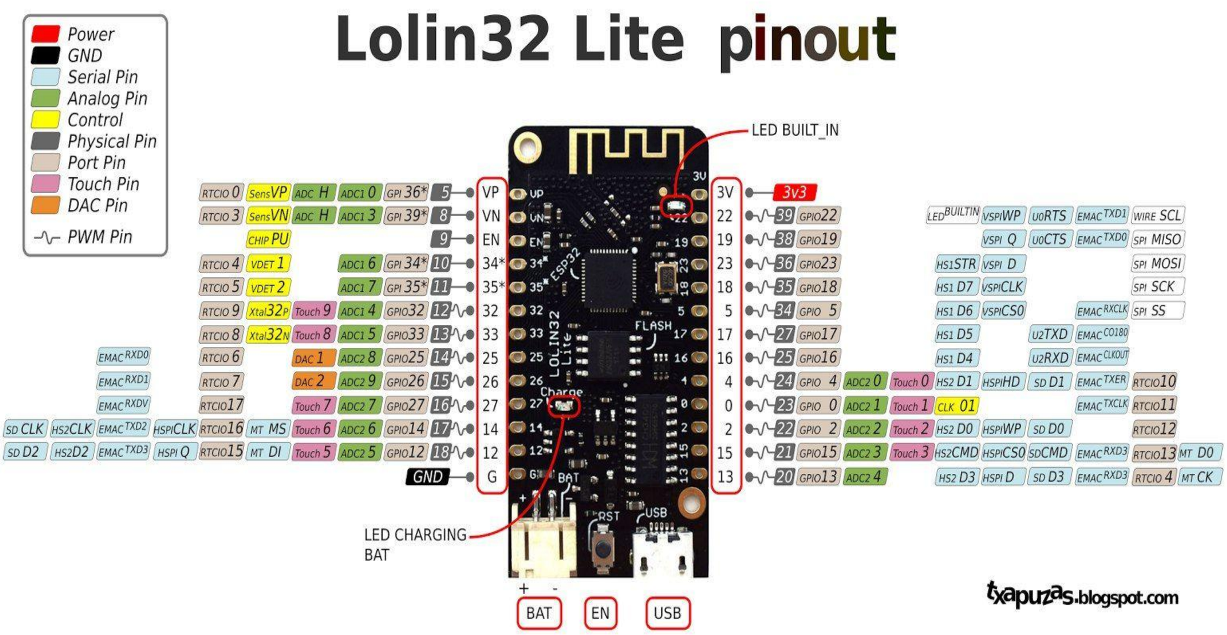
The base of the antenna is defined to fit an [ESP32](ESP32) made by expressif

The choosen model is [lolin lite]



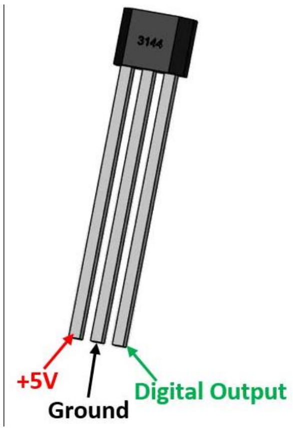
Any other ESP32board should work but could need to modify the base of the antenna.

The board is powered by a 5V smartphone USB power bank or charger.



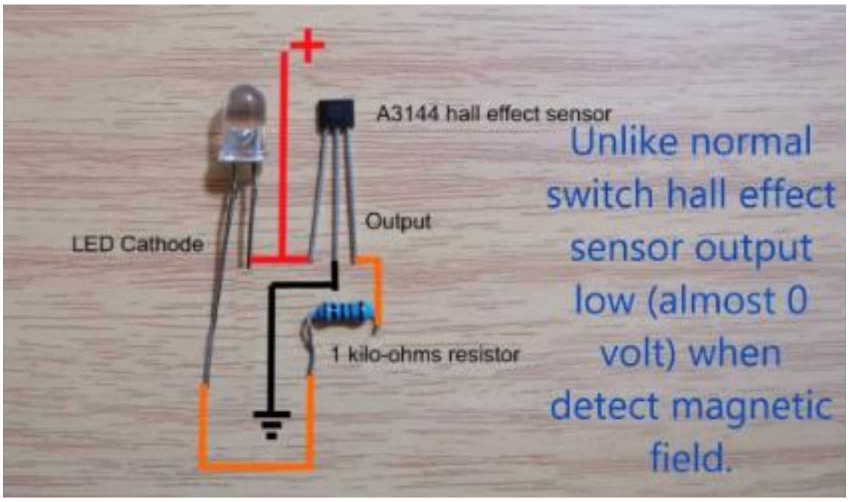
Hall sensors

The hall sensor switches are A3144 ones



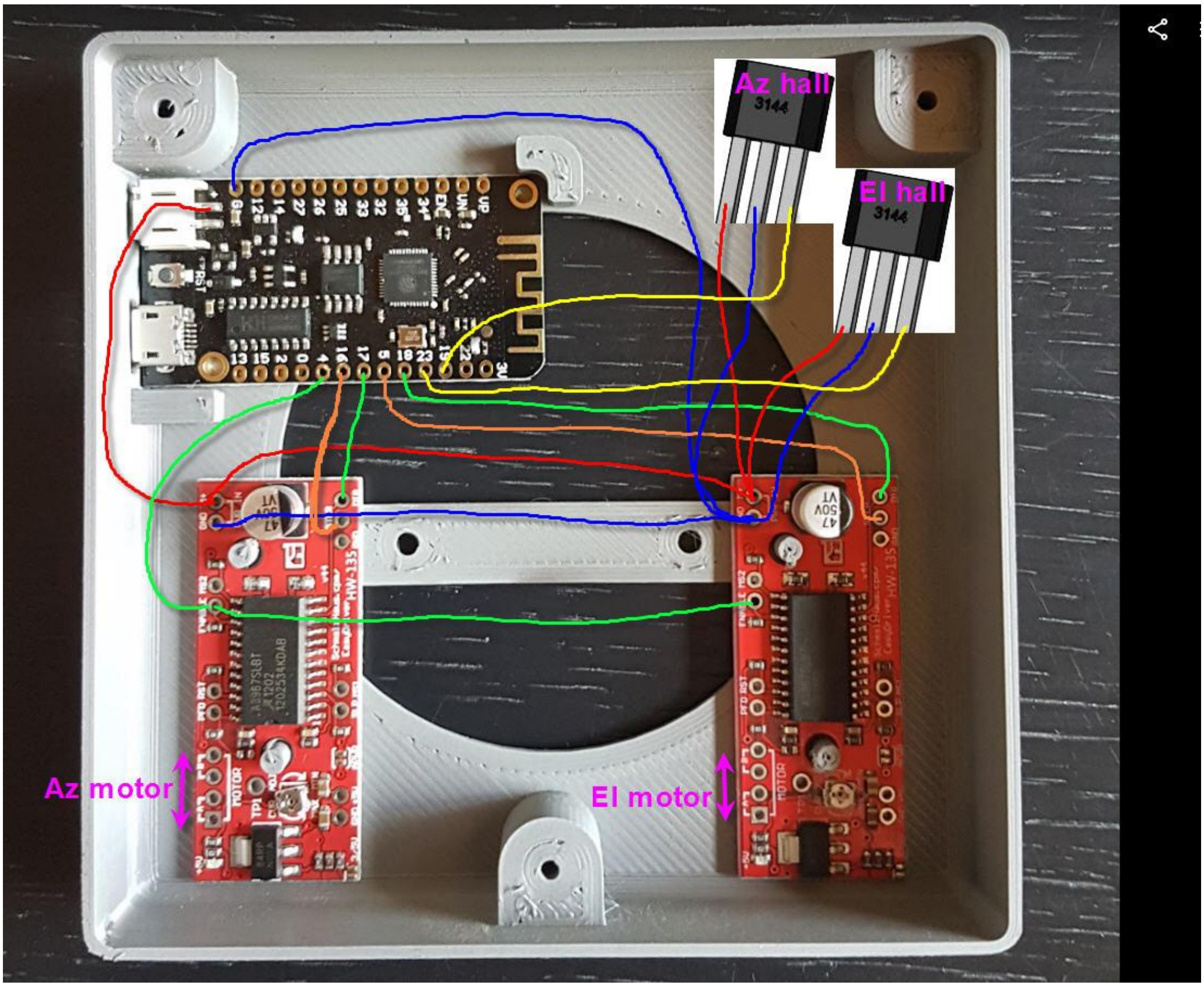
details here : https://www.alldatasheet.fr/datasheet-pdf/pdf/55092/ALLEGRO/A3144.html

Use this schematics if you want to test them :



Wirings

Solder all the connectors following this figure.



Note that

- the +5V is stolen from the battery connector (battery is unused) on the ESP32 board (red wires)
- all the grounds must be connected together (blue wires)
- connected to the ESP32 are:

```
// The Azimuth Stepper pins
#define AZ_DIR_PIN 17
#define AZ_STEP_PIN 16
// The Elevation stepper pins
#define EL_DIR_PIN 18
#define EL_STEP_PIN 5
#define ENABLE_PIN 4          //enable pin for both easysteppers boards

#define AZ_ZERO_PIN 19        //azimuth hall sensor
#define EL_ZERO_PIN 23        //elevation hall sensor
```

Firmware :

Firmware exits in two versions :

- Lite version: antenna is stand alone and tracks daily a fixed number of satellites, it fetchs TLE and time via Wifi.
- Pro version : antenna is stand alone but can be configured by an Android App, tracking is displayed in a real time on a map on your smartphone. Connexion between antenna and smartphone uses Bluetooth low energy. The App can send to the antenna all the TLE. Thus the antenna may not be connected to wifi. Fancy « accelerated motion » is offered as well as real time pass.

Lite version ESP32

It is directly inspired by the excellent source code provided by Alex Chang : https://github.com/alexchang0229/SatelliteTracker

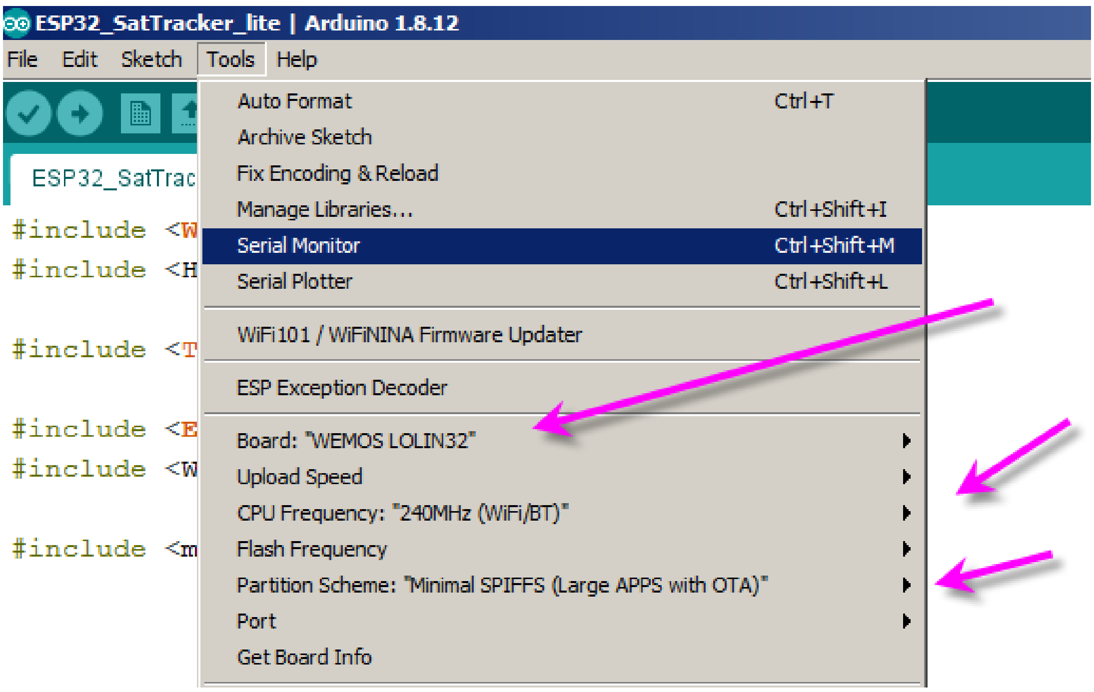
Main improvements are :

- The two cores of the ESP32 are used, one to compute predicted orbits, the other for steppers motion.
- Orbit computation is done once every 1 or 2 ms, motion is much smoother
- Stepper drivers are easydrivers boards
- An optional boot mode allows to reach the hall sensors to find “north” and “horizon”

Installation and config

Install arduino IDE and configure it for ESP32 boards : https://github.com/espressif/arduino-esp32

Then configure the IDE like this :



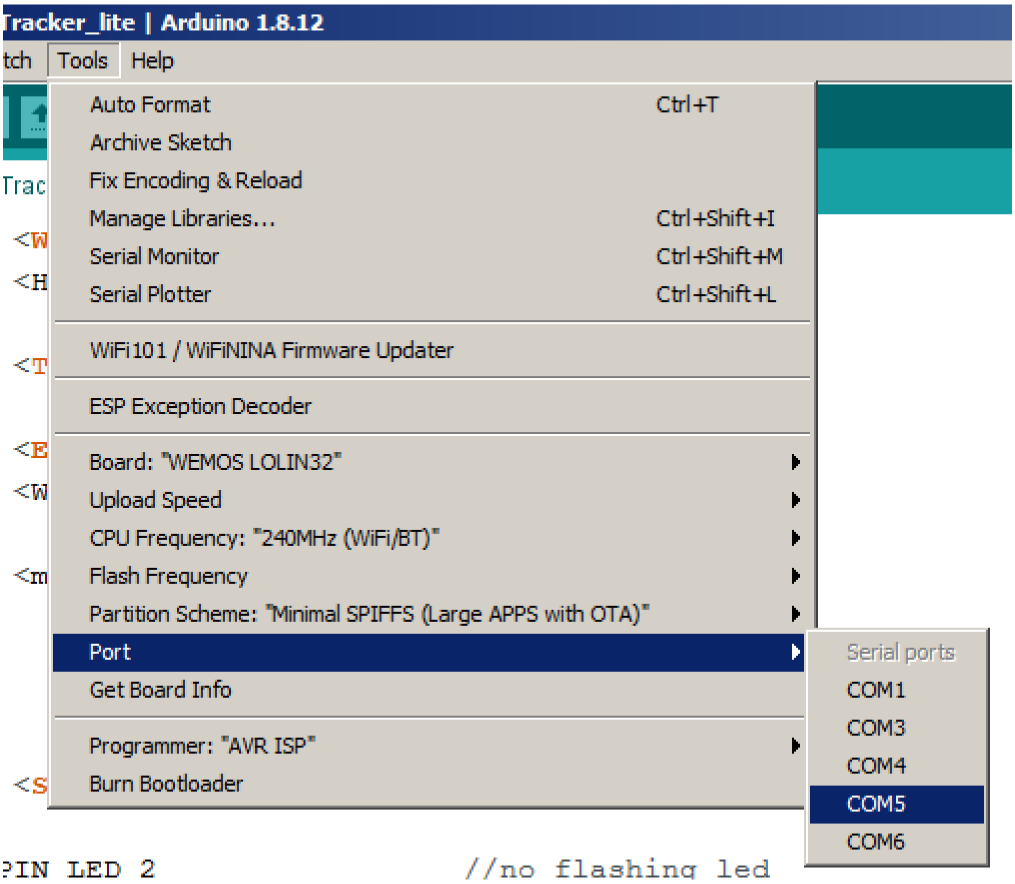
Install these libraries :

#include <TimeLib.h> : https://github.com/PaulStoffregen/Time

#include <Sgp4.h>: https://github.com/Hopperpop/Sgp4-Library

#include <AccelStepper.h>: https://www.airspayce.com/mikem/arduino/AccelStepper/

Plug your usb cable to power the board, a COM port should appear, select it in the IDE



You can compile the APP and upload it automatically to your board.

You should modify the code for your configuartion :

Set your credentials here :

```
//wifi
String ssid = "YOUR_SID";                              //can be changed in Pro version
String password = "YOUR PASSWORD";                      //can be changed in Pro version
```

Set your station longitude and latitude here :

```
float myLat = 43.5156, myLong = 1.49806, myAlt = 230 ;    //Antenna latitude, longitude and altitude . (fixed in lite version)
```

And select the satellites to track here :

```
//SGP4
#define NB_SAT 10
int nbSat = 5;                                                  //Number of satellites to track. (up to ten in Pro version)
char TLE[500];                                                  //Variable to store satellite TLEs.
char satnames[NB_SAT][30] = {0};                                //Names of satellites. (found here : https://www.celestrak.com/satcat/search.php)
String startURL = "/satcat/tle.php?CATNR=";
int satID[NB_SAT] = {25544, 38012, 41457, 38755, 43662};       //ID of Celestrak TLEs for satellites. (fixed in lite version)
//(https://www.celestrak.com/satcat/tle.php?CATNR=39019)

char TLE1[NB_SAT][70]; char TLE2[NB_SAT][70];

float myLat = 43.5156, myLong = 1.49806, myAlt = 230 ;    //Antenna latitude, longitude and altitude . (fixed in lite version)
```

In the source 5 satellites are tracked (max 10)

Their ID are : 25544, 38012, 41457, 38755 and 43662

You can track what you want, simply search satellites ID on celestrack :
https://www.celestrak.com/satcat/search.php

Example search for PLEIADES andget the Norad ID :

Search parameters:

- Name: PLEIADES
- Filters: Payloads
- Return first 500 items

Show 25 entries   Search:

International Designator	NORAD Catalog Number	Name	Source □	Launch Date	Launch Site □	Decay Date	Status □	Latest Data □
2011-076F □ □	38012	PLEIADES 1A □	FR	2011-12-17	FRGUI		+	□ □
2012-068A □ □	39019	PLEIADES 1B □	FR	2012-12-02	FRGUI		+	□ □

Notes:
□ Link to additional information
□ Link to custom search query for related news, information, and images
□ Link to raw TLE data
□ Link to interactive orbit visualization, using AGI's open-source Cesium JavaScript library, developed and provided by our partners at Digital Arsenal
□, □, and □ in the International Designator column are for all objects associated with that launch

Finally if your antenna does not have hall sensors, simply comment out this line :

```
#define HALL_SENSORS              //comment this line if no hall sensors
```

Pro version ESP32

This version is not available freely, please contact me.

Pro version Android

This version is not available freely, please contact me.