Betta hide yo downlinks

Building a budget-friendly Az/El dish tracker

Cyberspectrum Las Vegas 2017

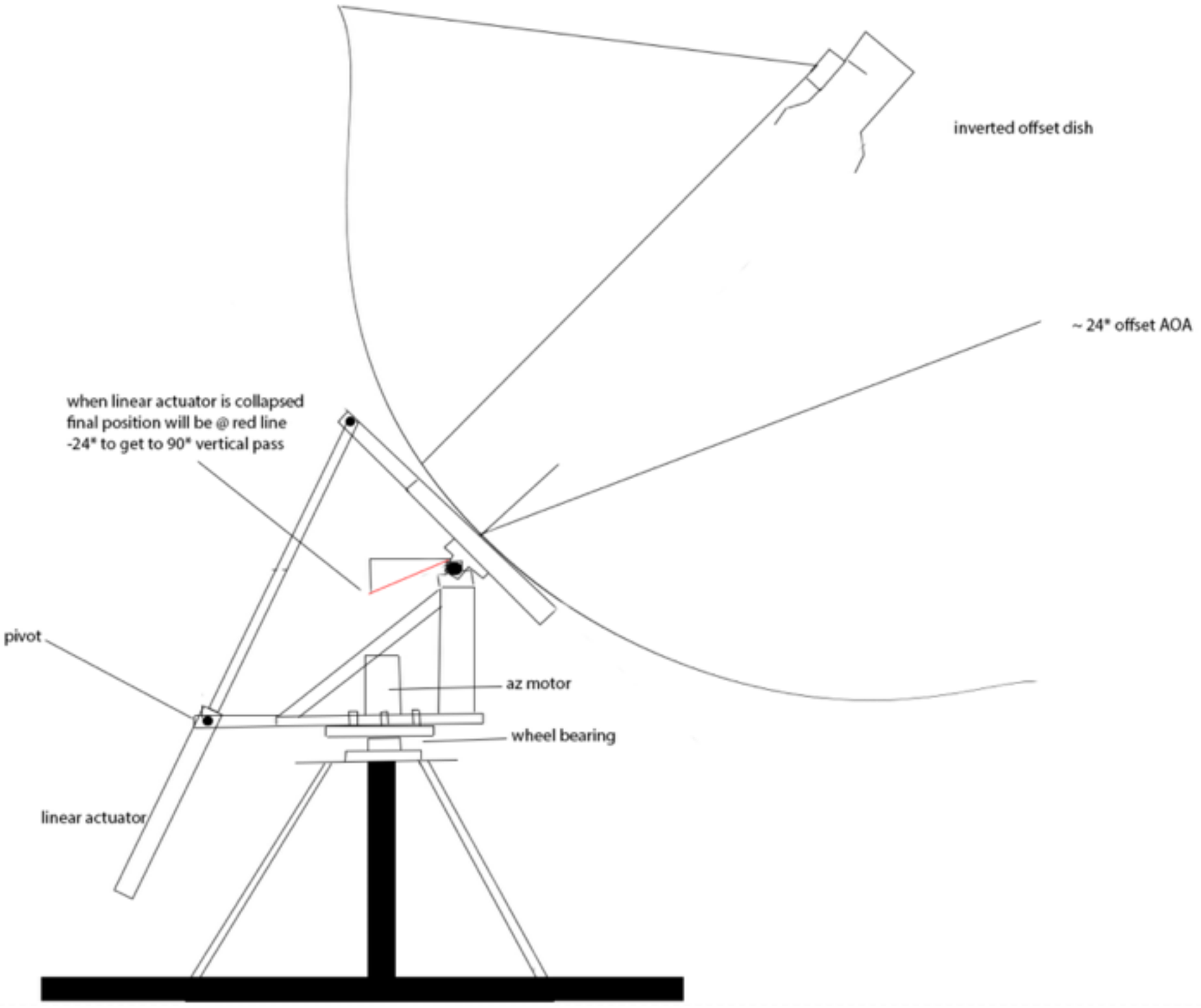
@devnulling - github.com/devnulling

Why?

- Off-the-shelf Az/El trackers can be expensive
- APT is done after NOAA-19
- HRPT / LRD / HRD will be around for a while
- Lots of other interesting LEO birds
- Amateur DSN / RA / EME
- Manually adjusting/moving a dish is not fun

In the beginning...

there was an idea and a really bad drawing



Tools Required

- Basic metal working tools
  - Welder/Gear ($90-200)
  - Grinder/Discs ($30)
  - Drill ($20)
  - Safety gear ($20-30)
  - Misc hand tools ($50-100)
  - Hammer, punches, drill bits, files, measuring tools, etc.
- Nice to have but not required
  - Drill press
  - Cutting Torch
  - Metal Brake
  - Chop saw
  - Vice
  - CNC
  - Lathe

Harbor Freight has inexpensive tools.
Not the greatest, but will work for light projects.

Check with and join your local hacker / maker space.
They may have metal working equipment
or a member may have equipment that can be used.

Where to get a dish?

- Craigslist

- Look for them!
  - A lot of old C-Band dishes (6-12ft) can be had for ~$50. Sometimes free just to remove it. Most people are happy to get them out of their yards.

- Ebay / New (Can be expensive)

Where to get the material?

- Call around / visit local metal working/fabrication shops

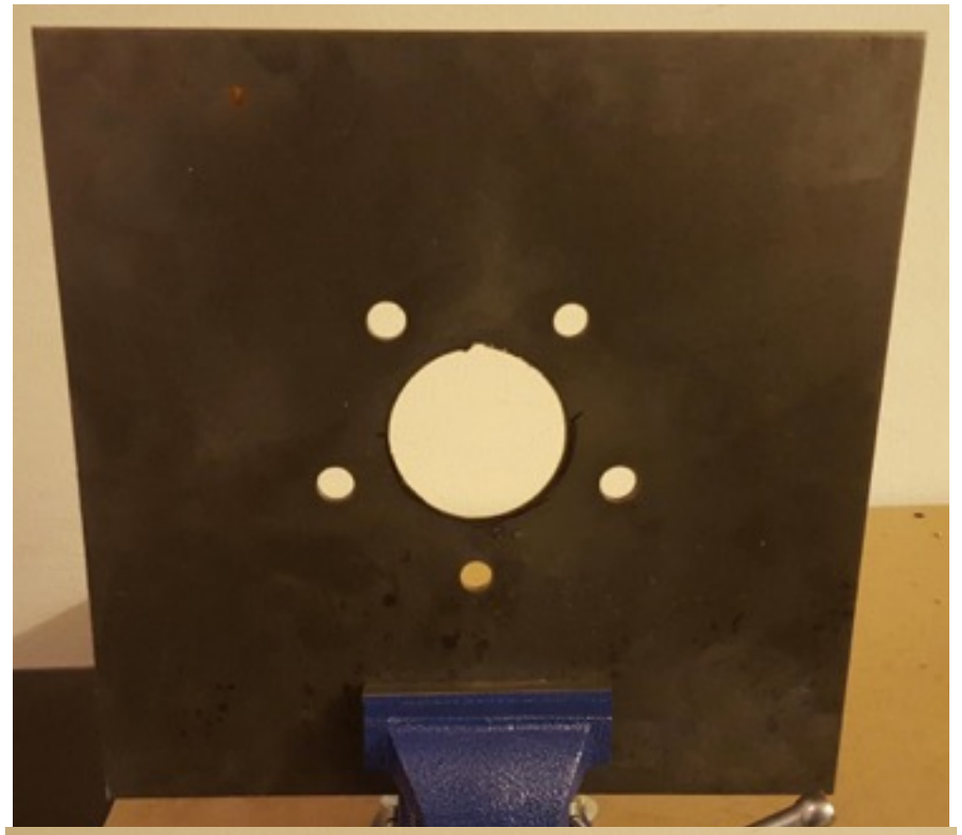
- Often have scrap bins / area where material can be bought by the pound for extremely cheap

- Ebay!
  - Hard to find materials and remnants for okay pricing

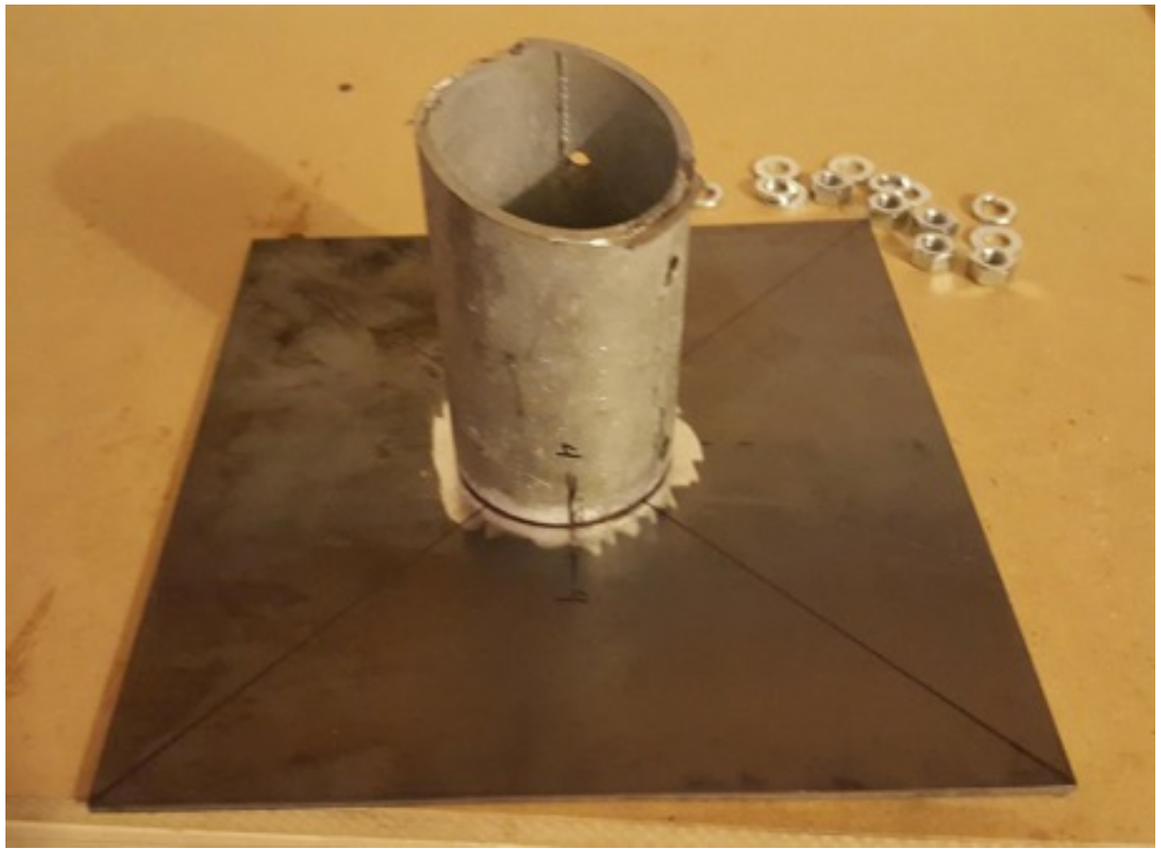
Where to get other parts?

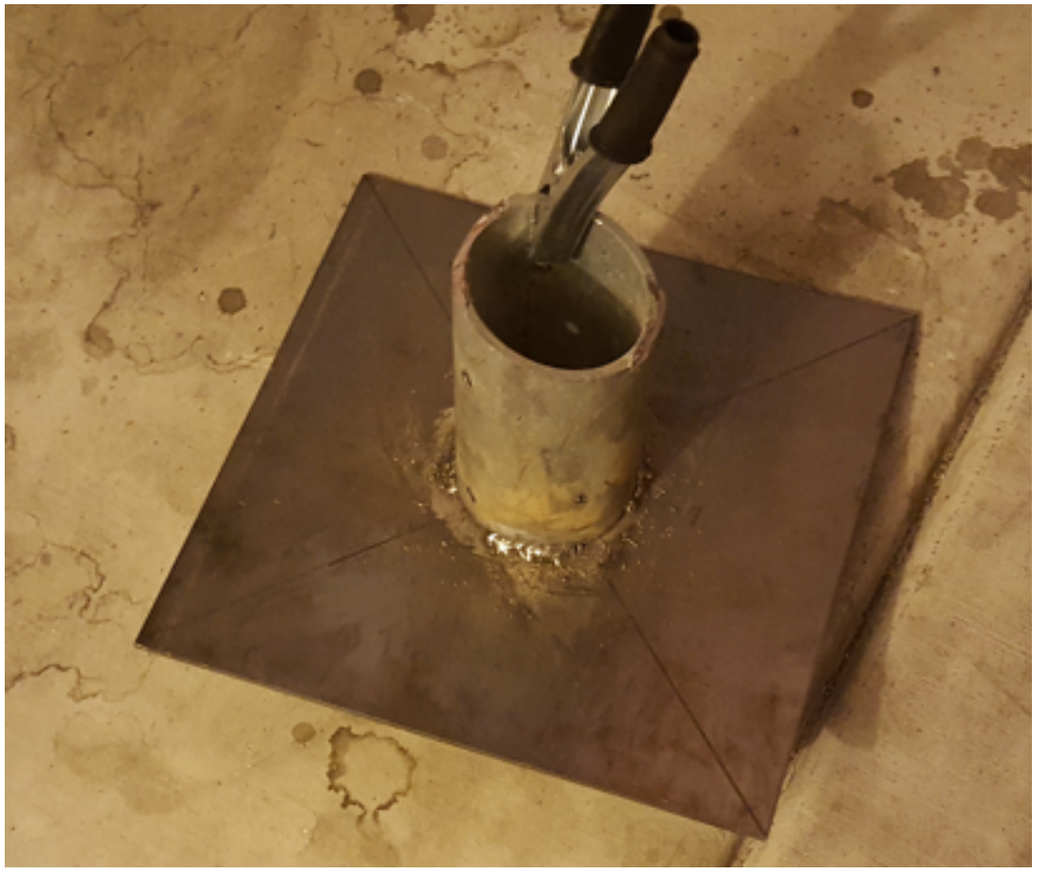
- Ebay
- Hardware store (Home Depot, Lowes)

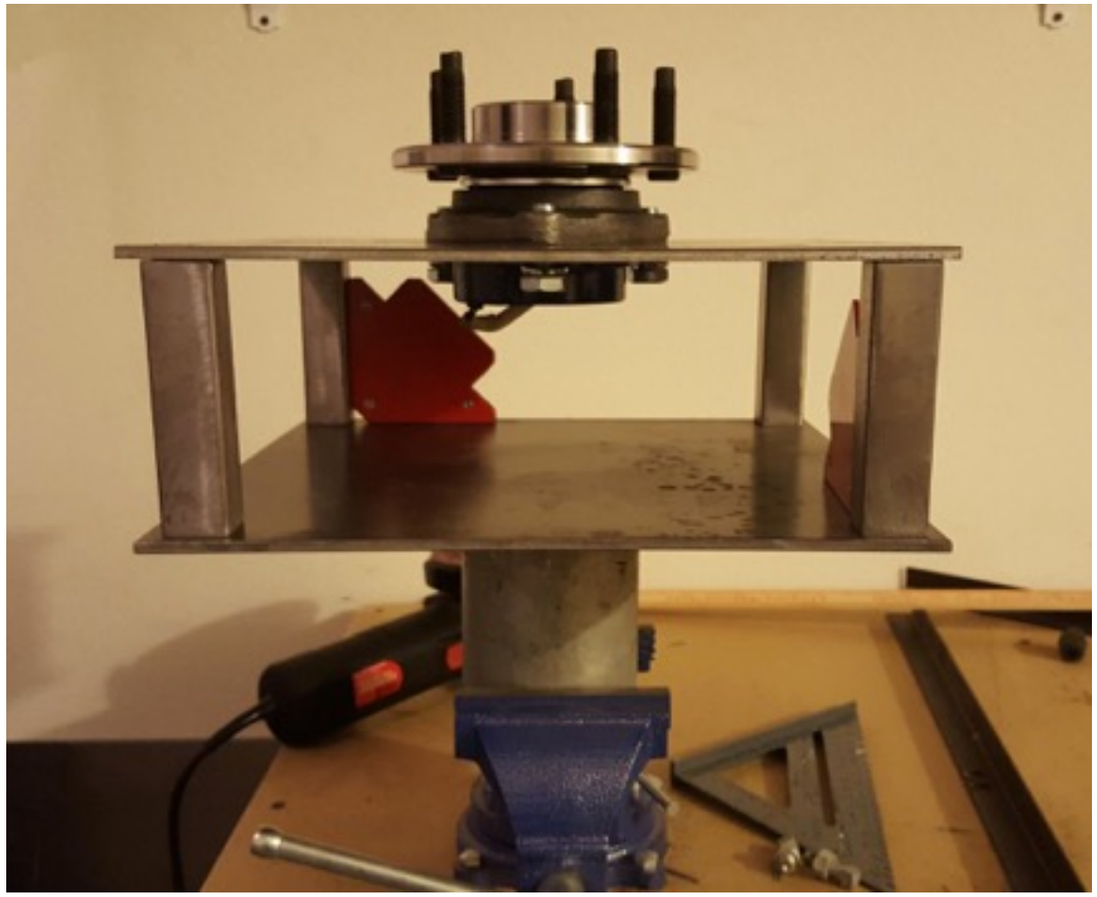
Lets get started

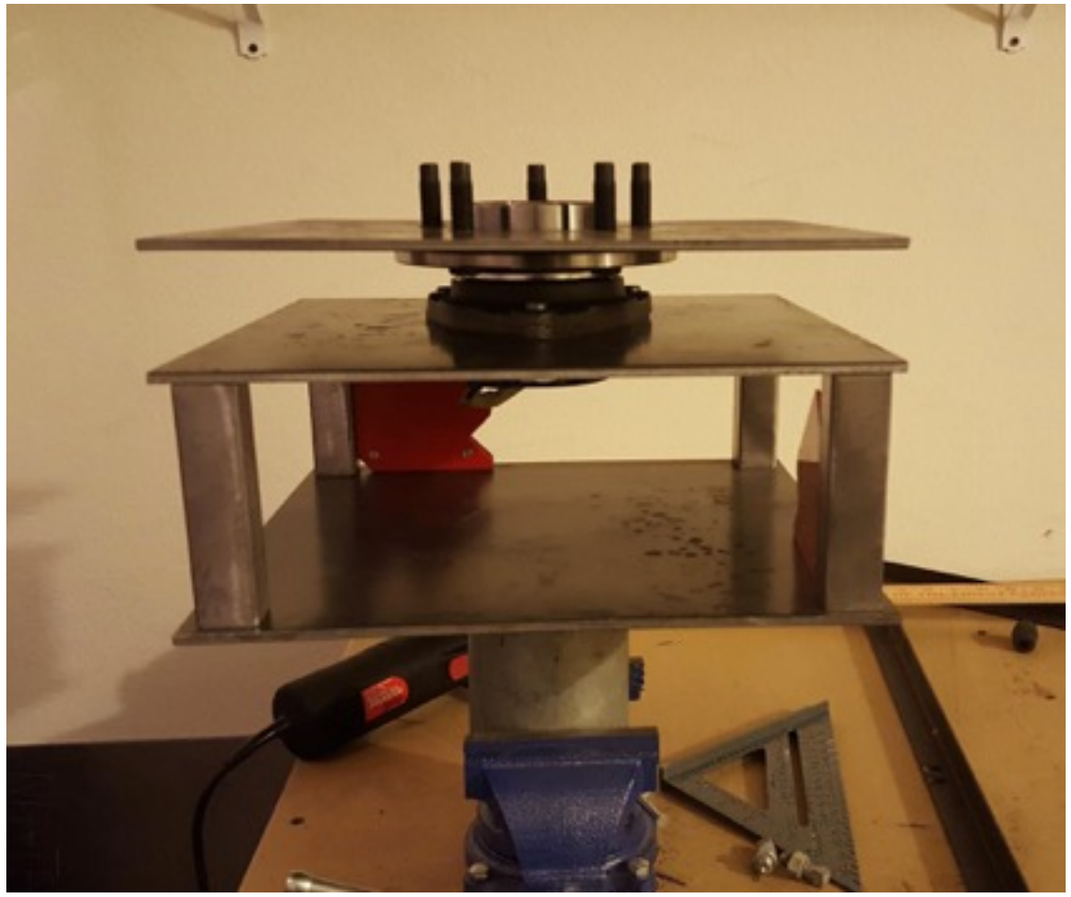


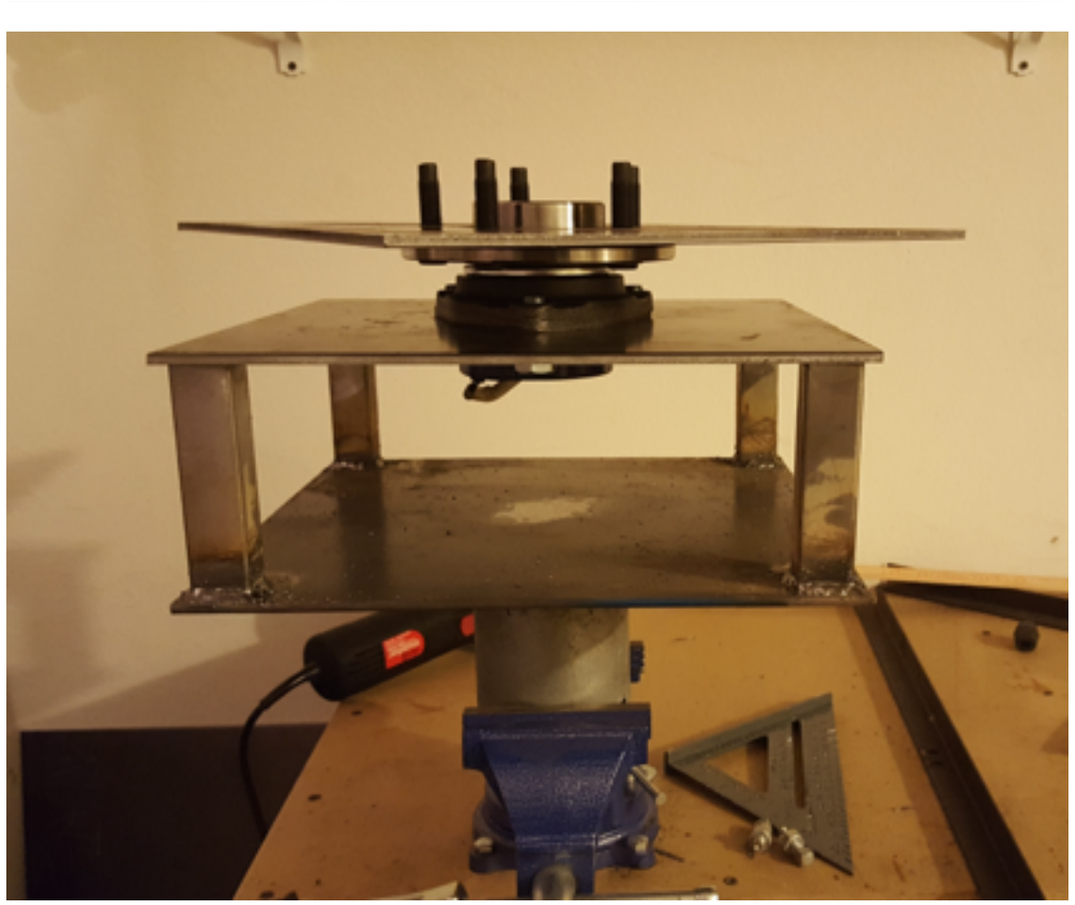
Air tools are nice to have too,
but a file will work just as well.

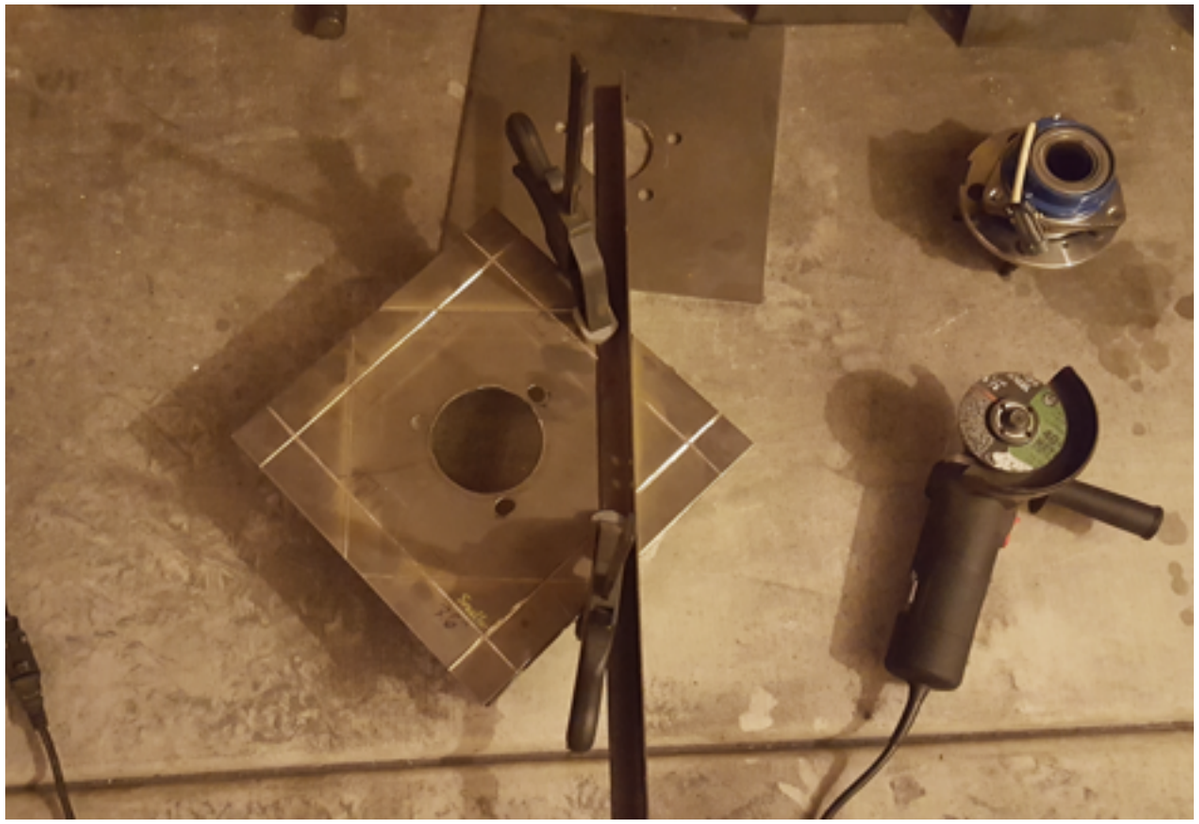


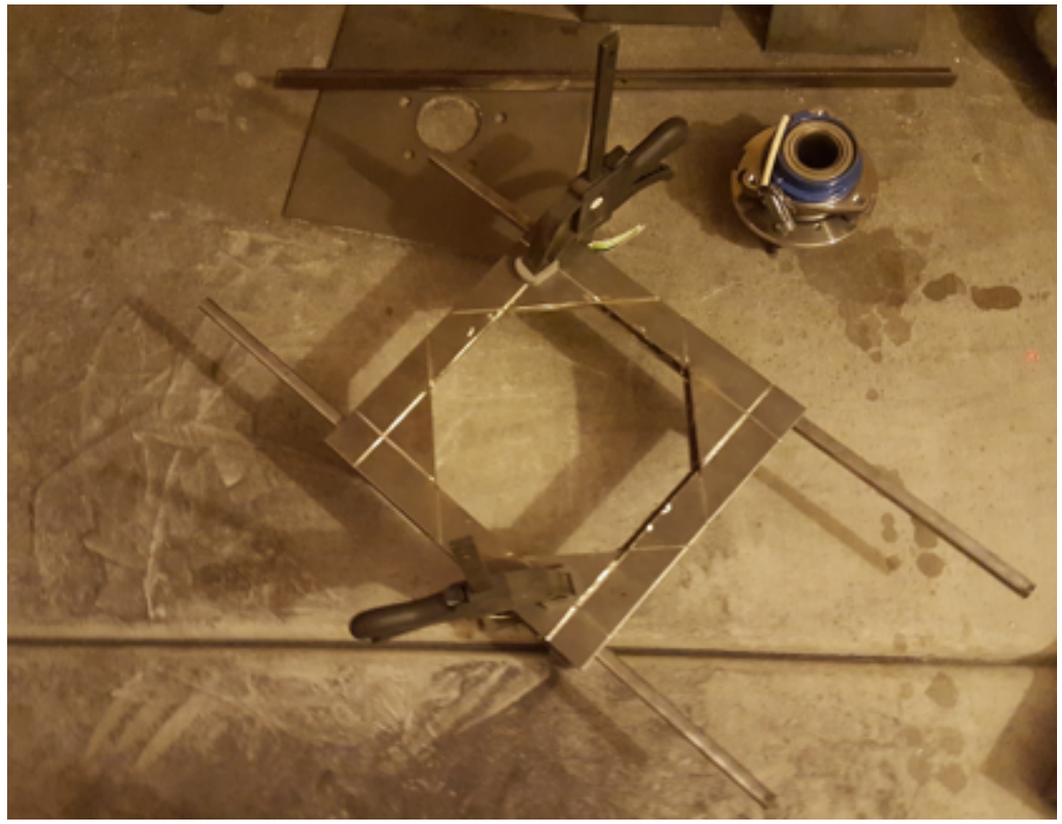


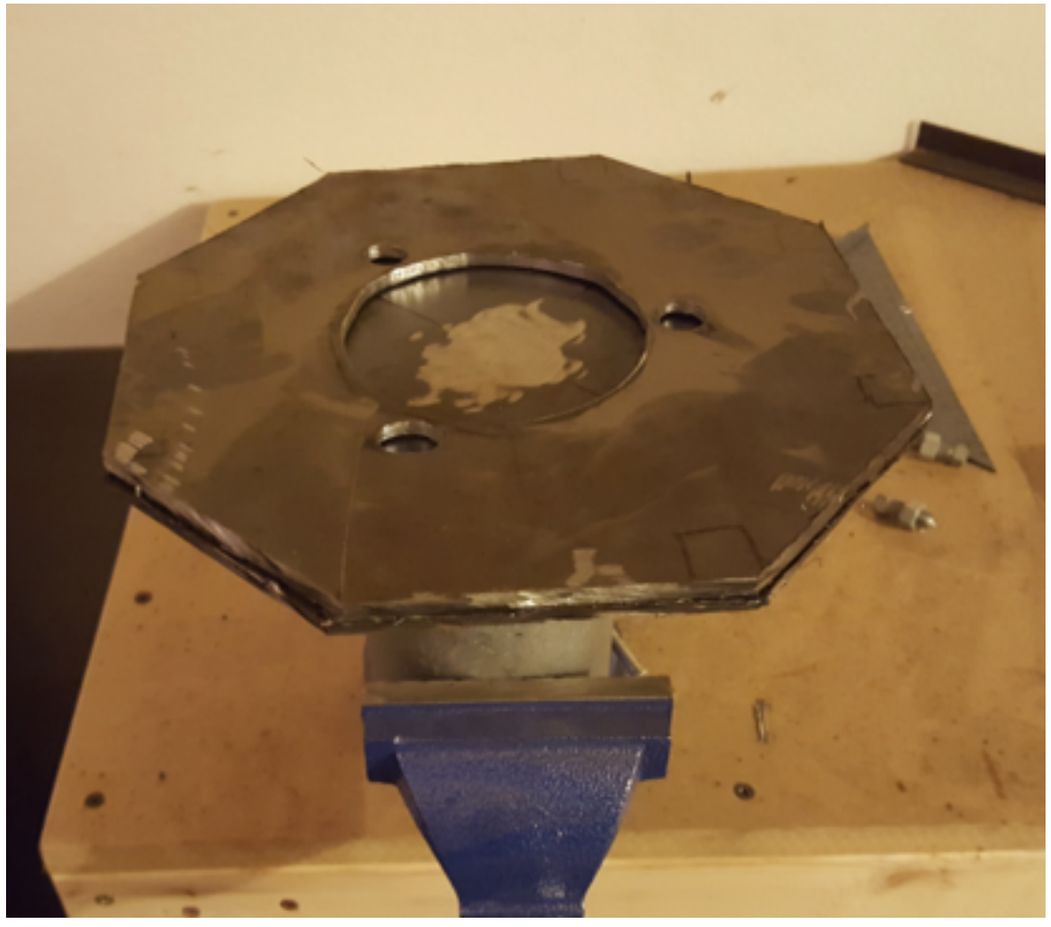


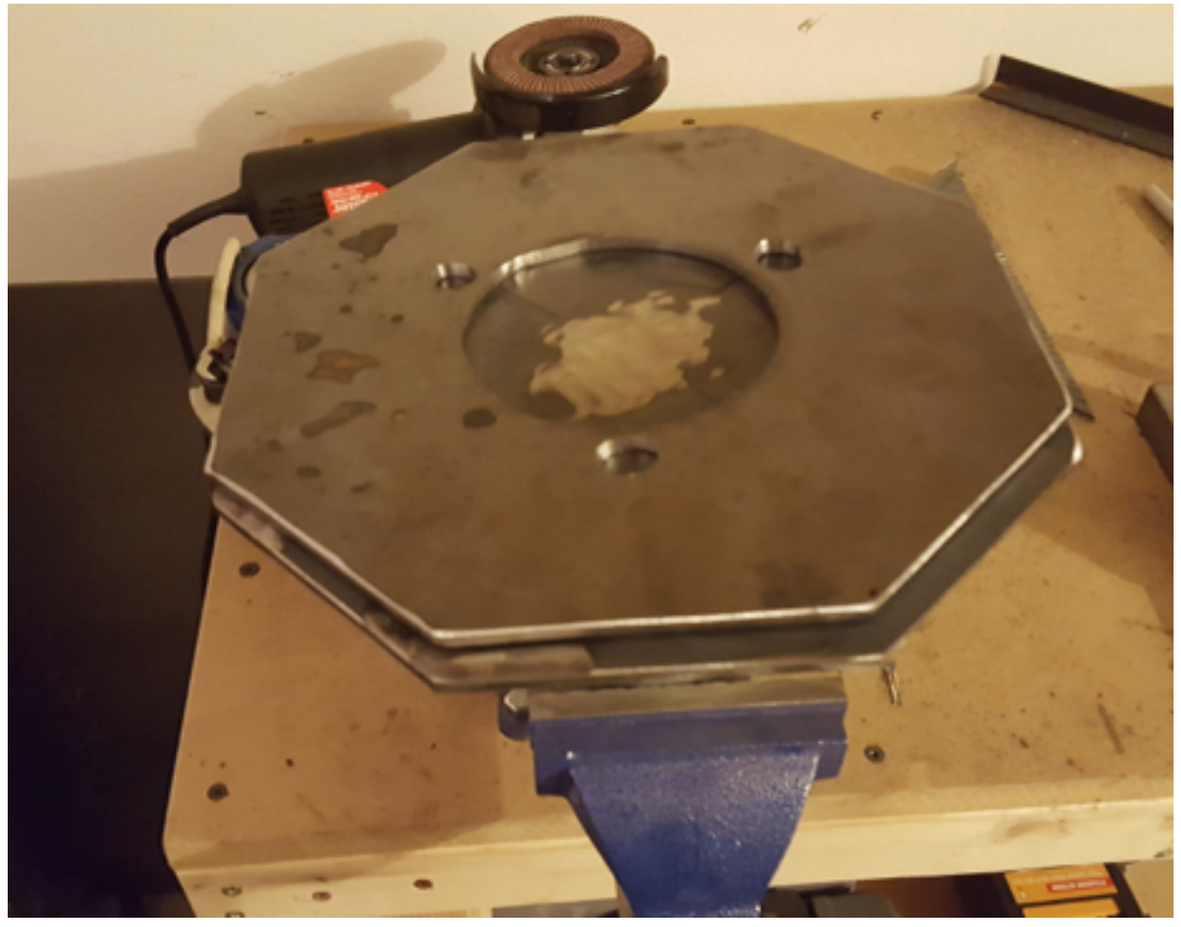


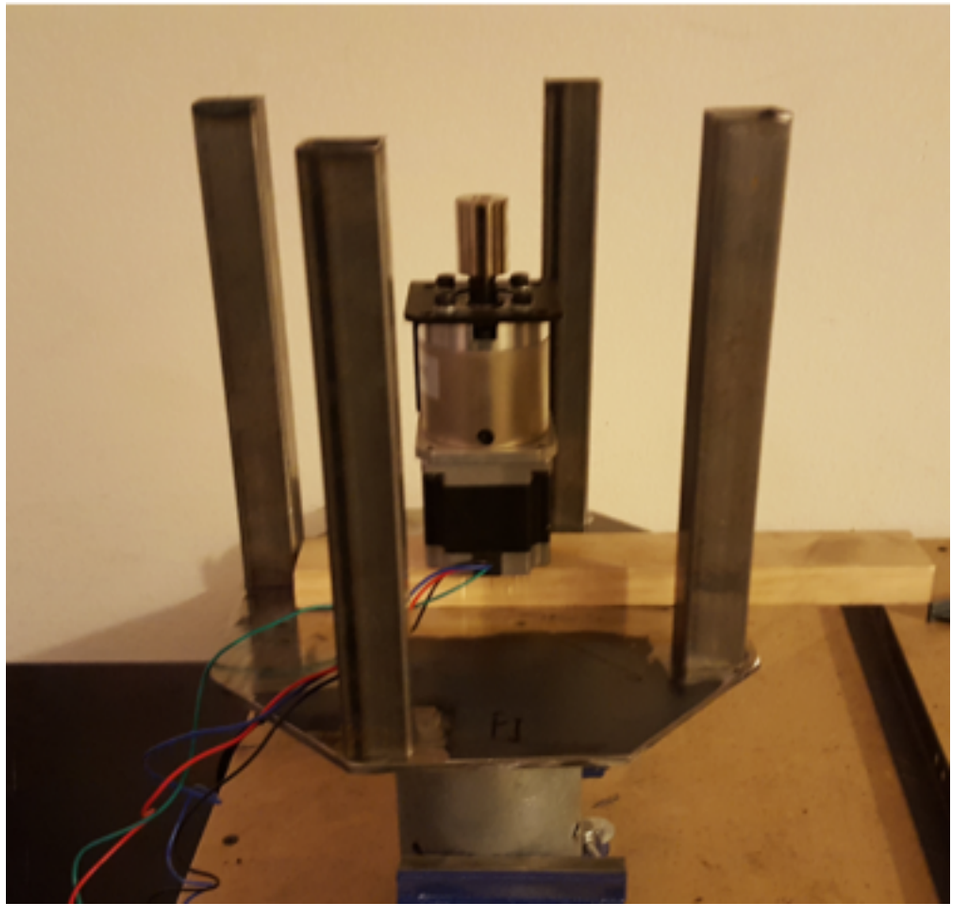


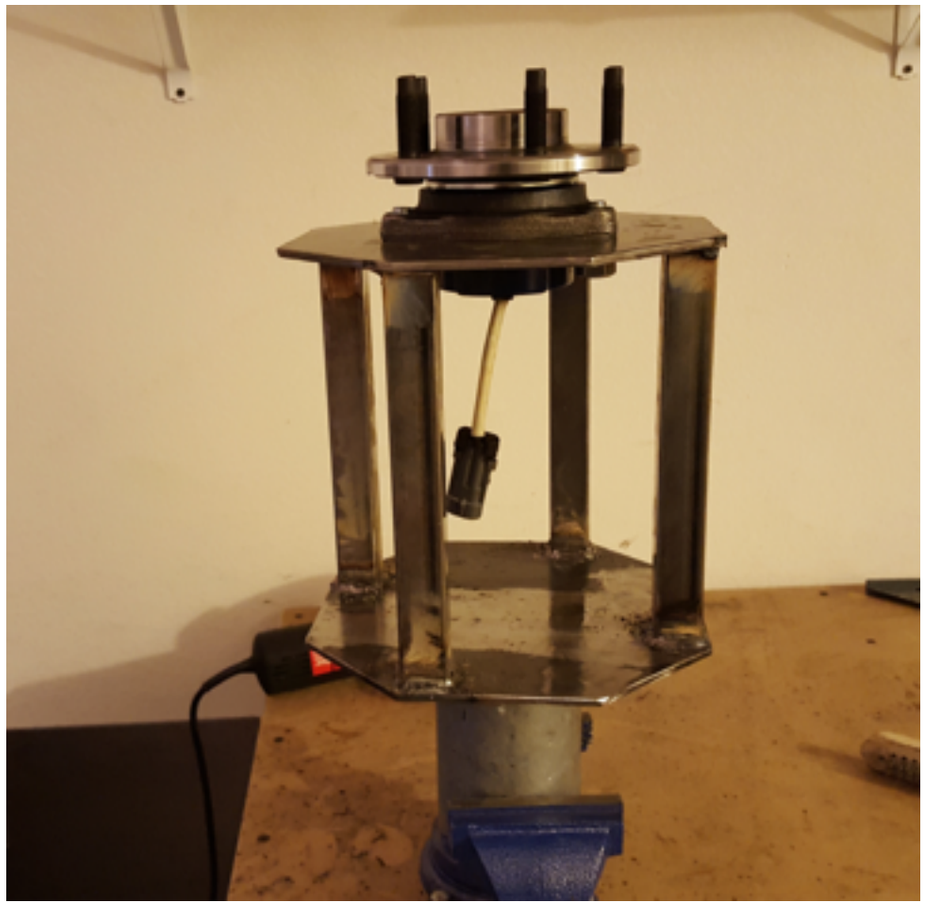


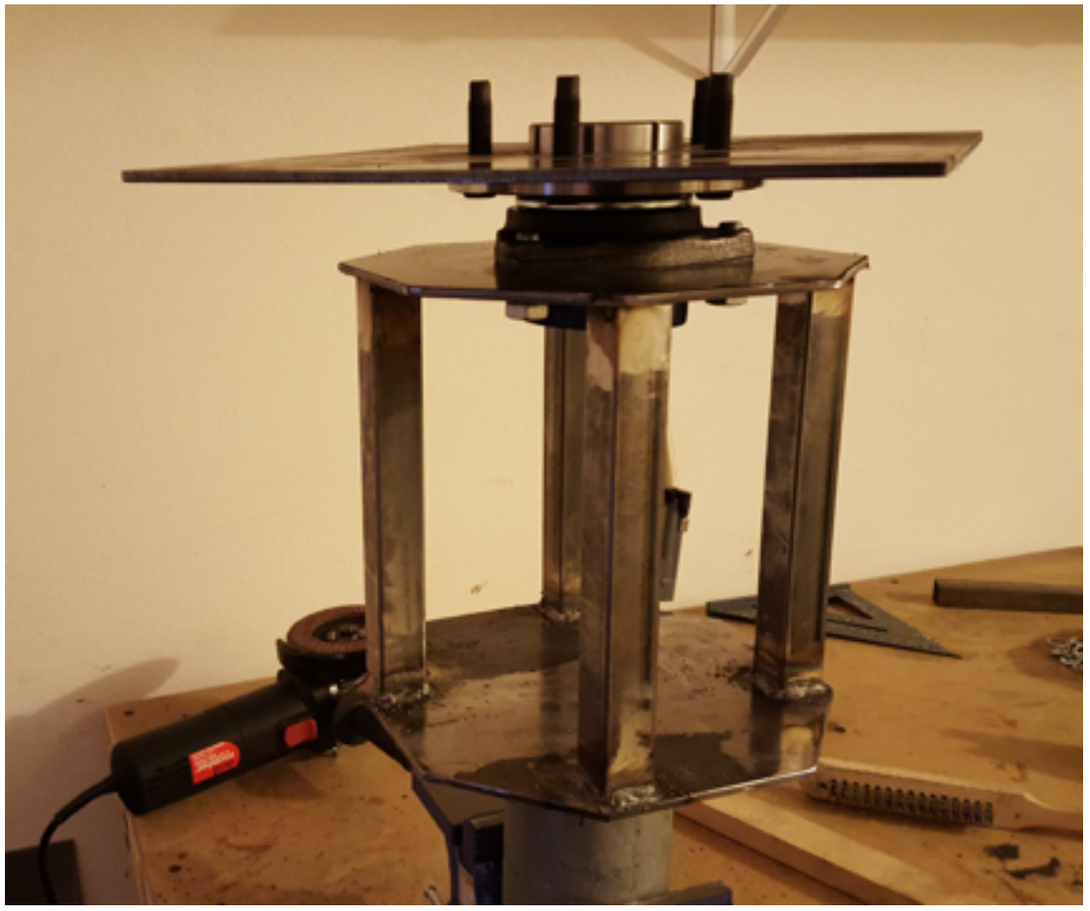


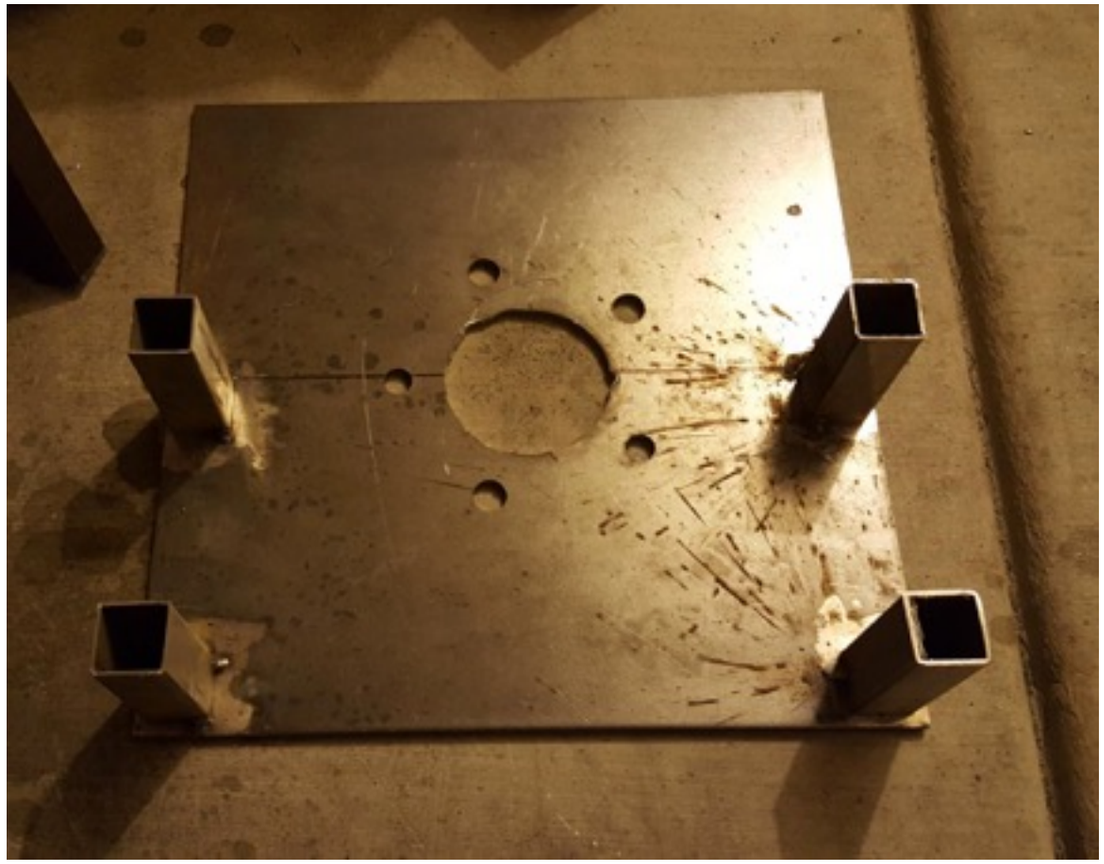


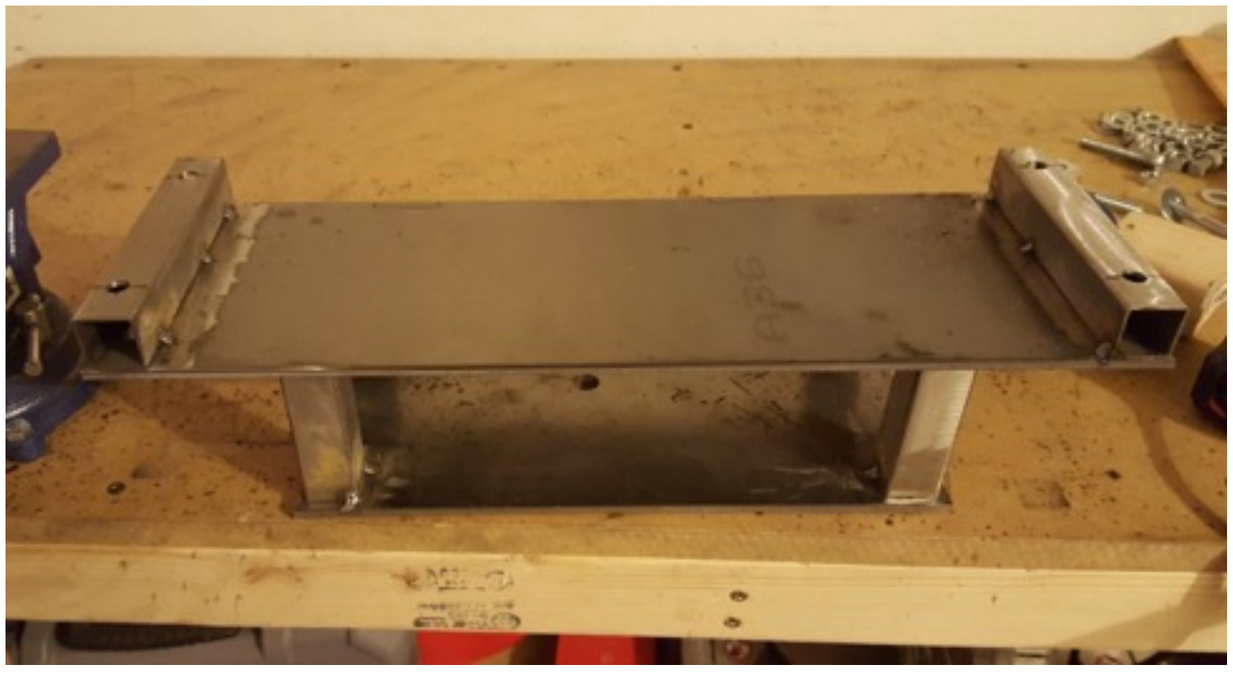


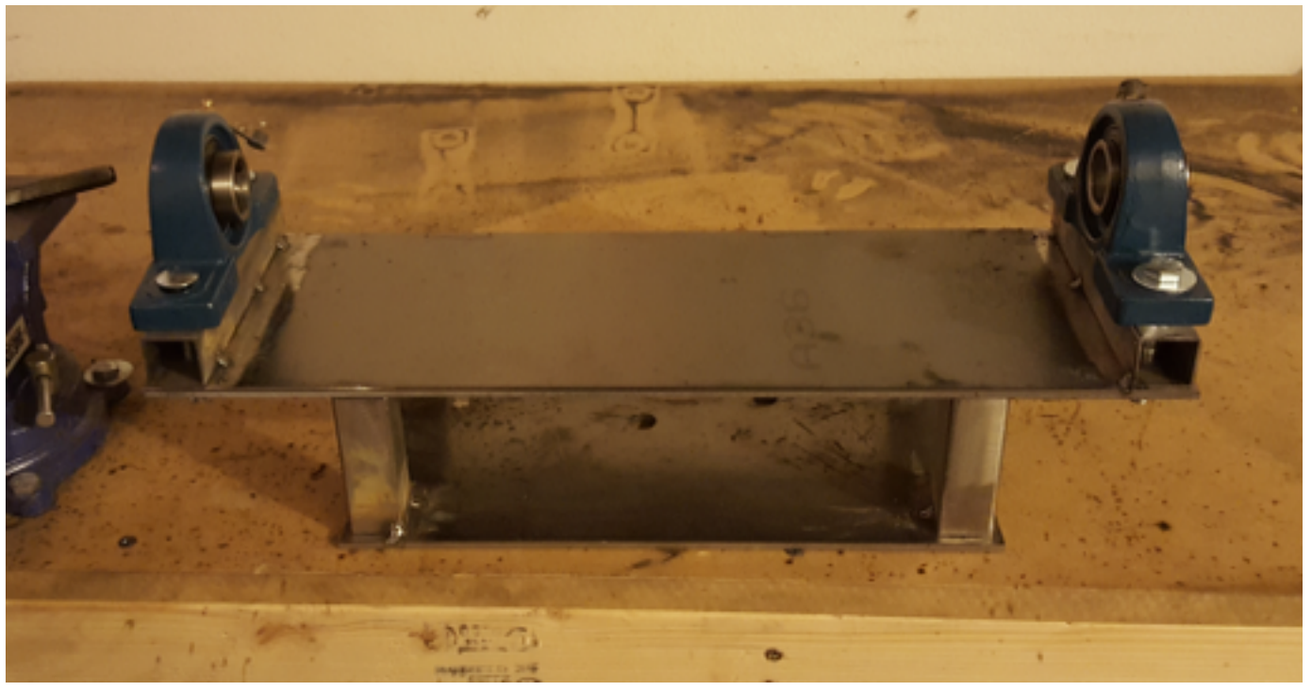


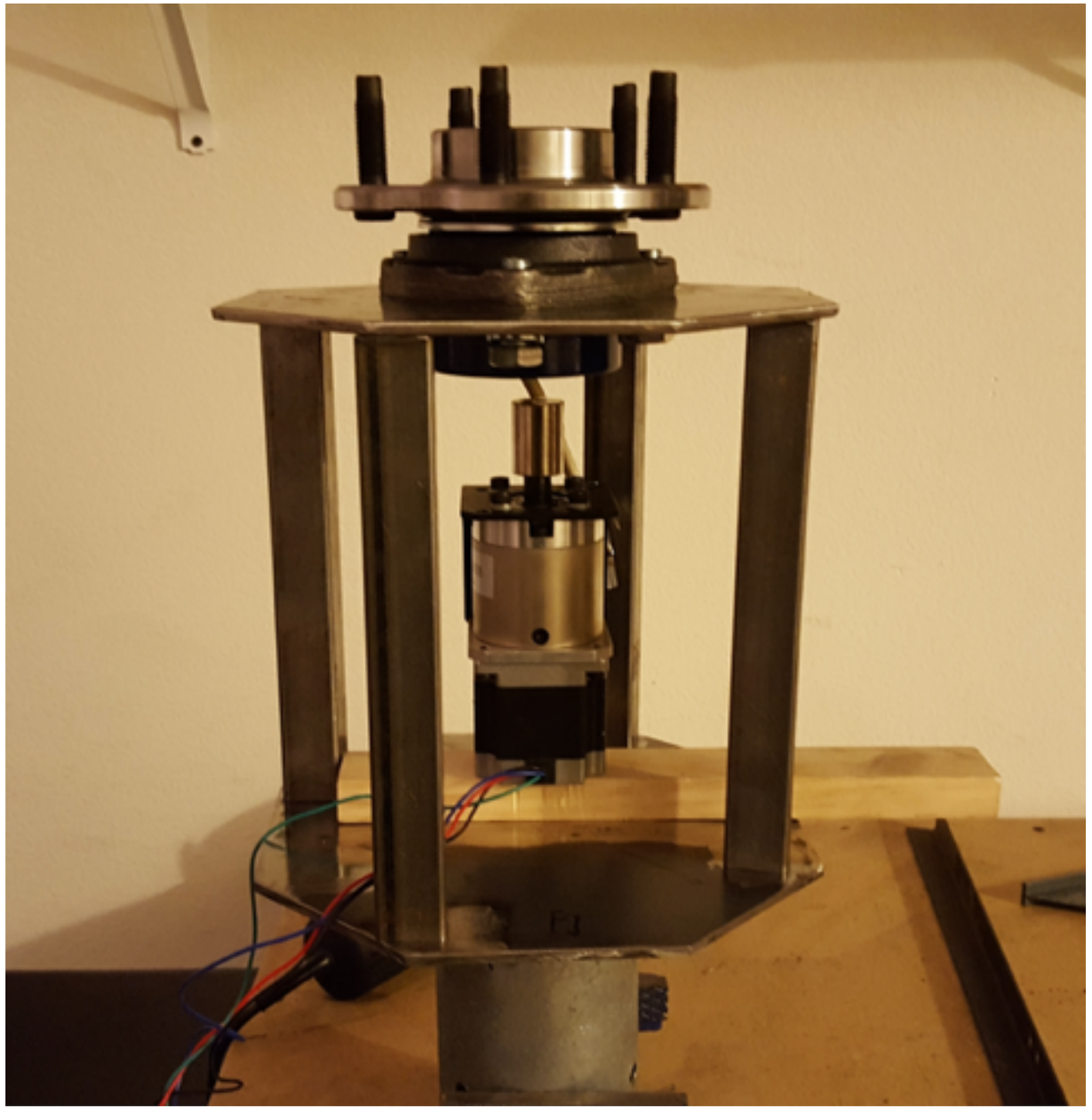


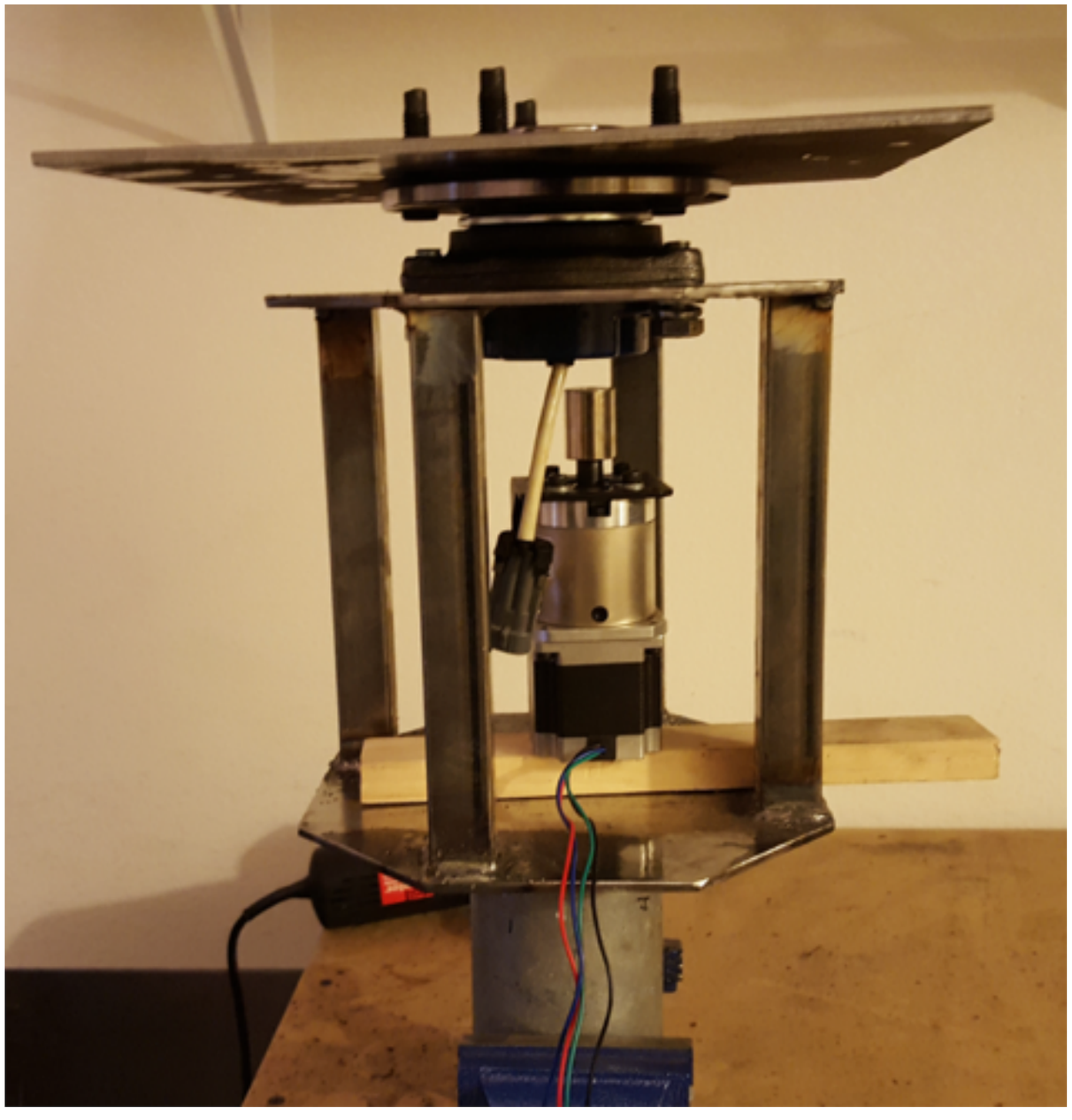


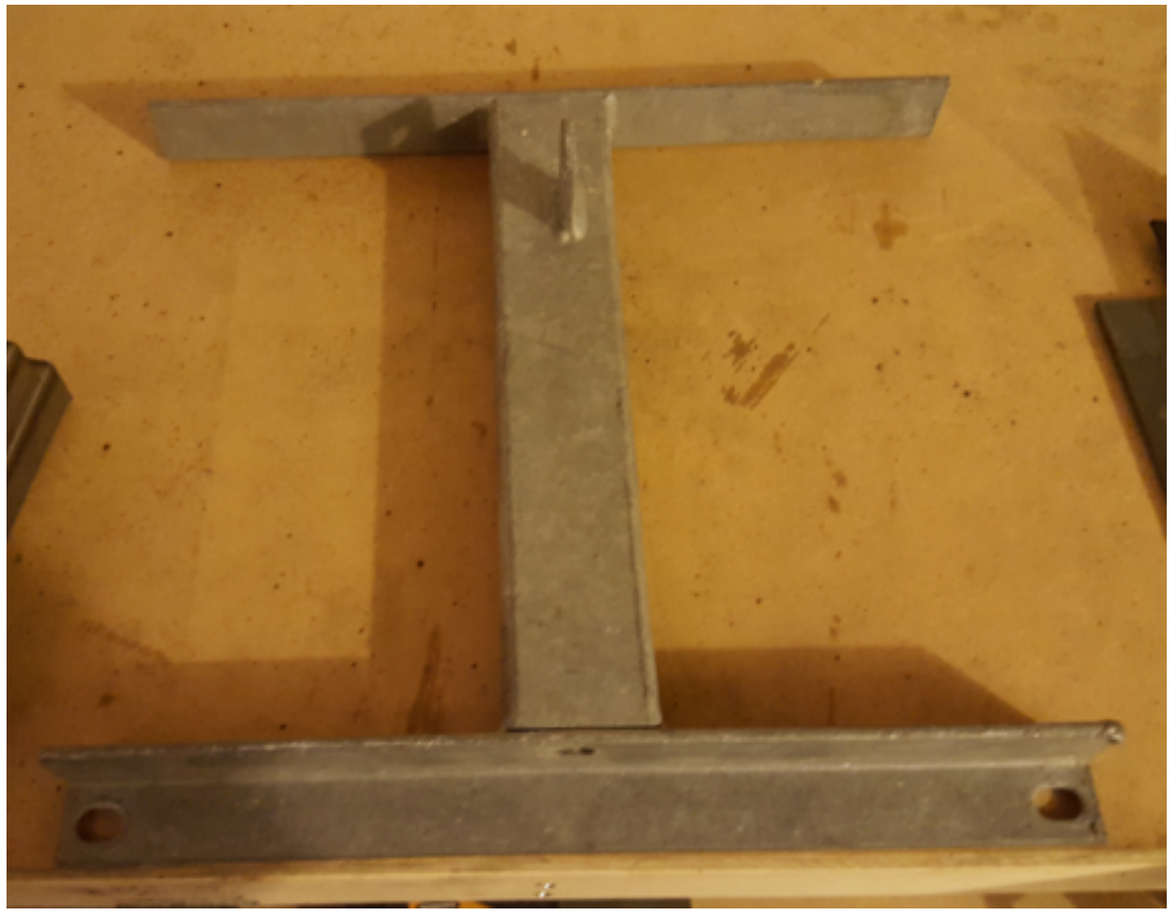


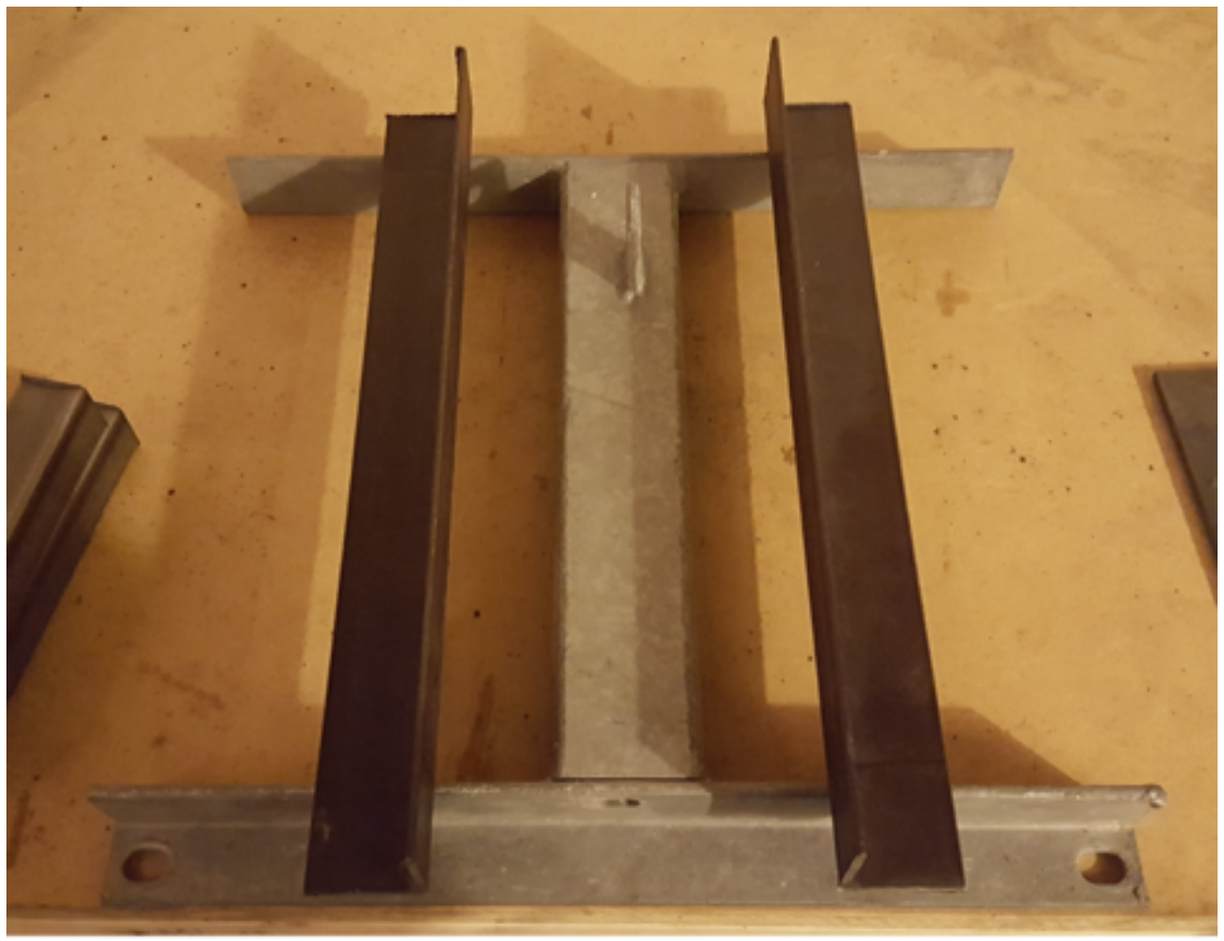


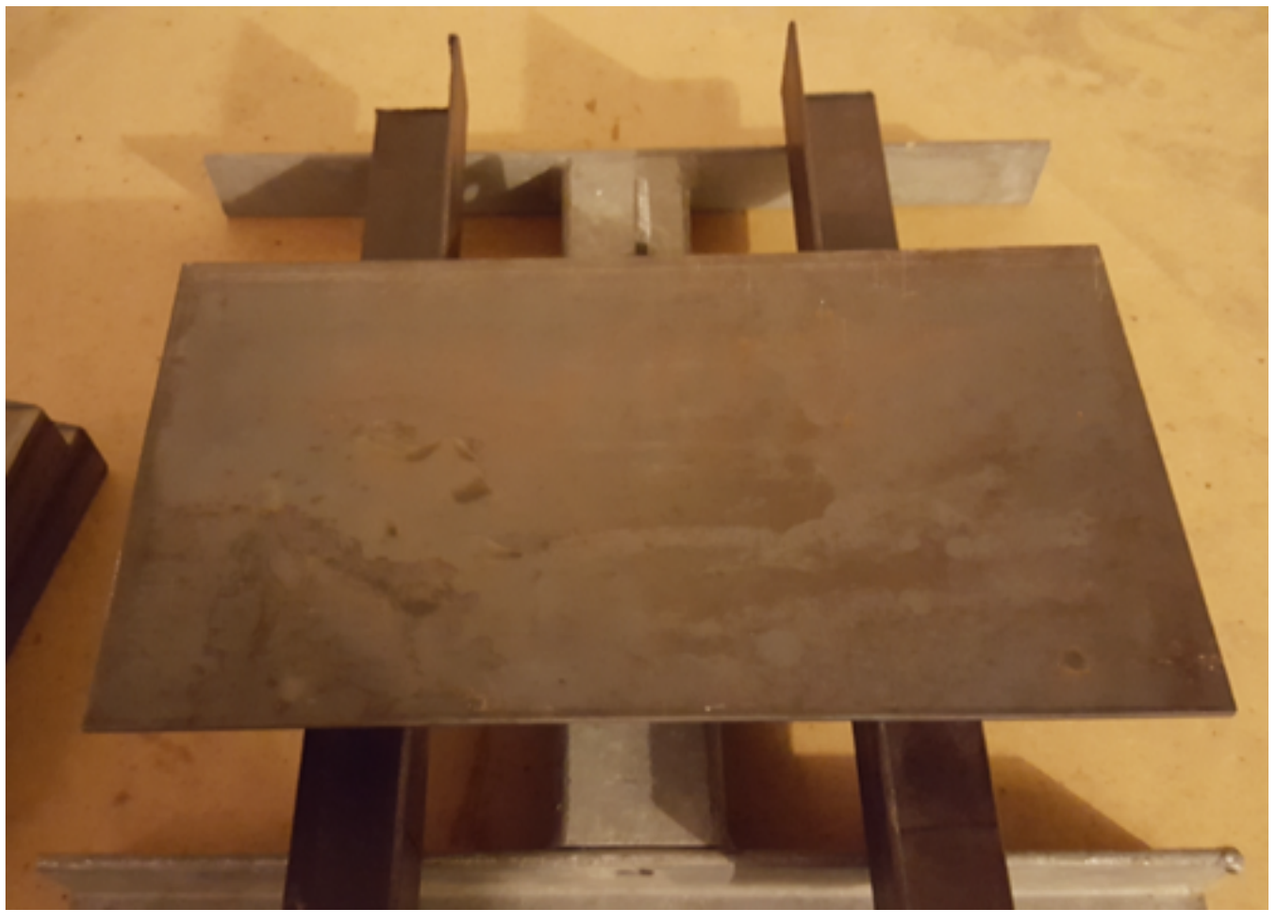


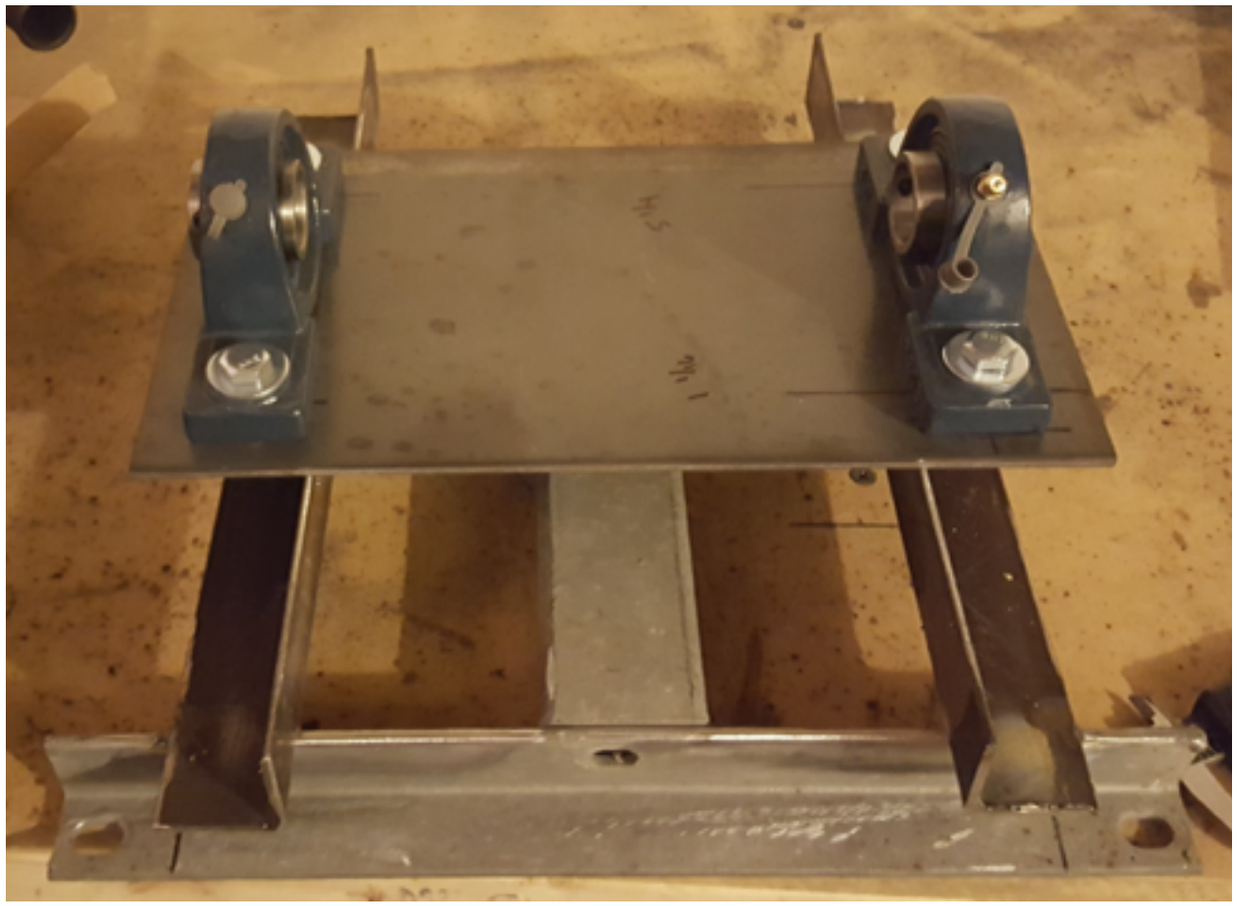


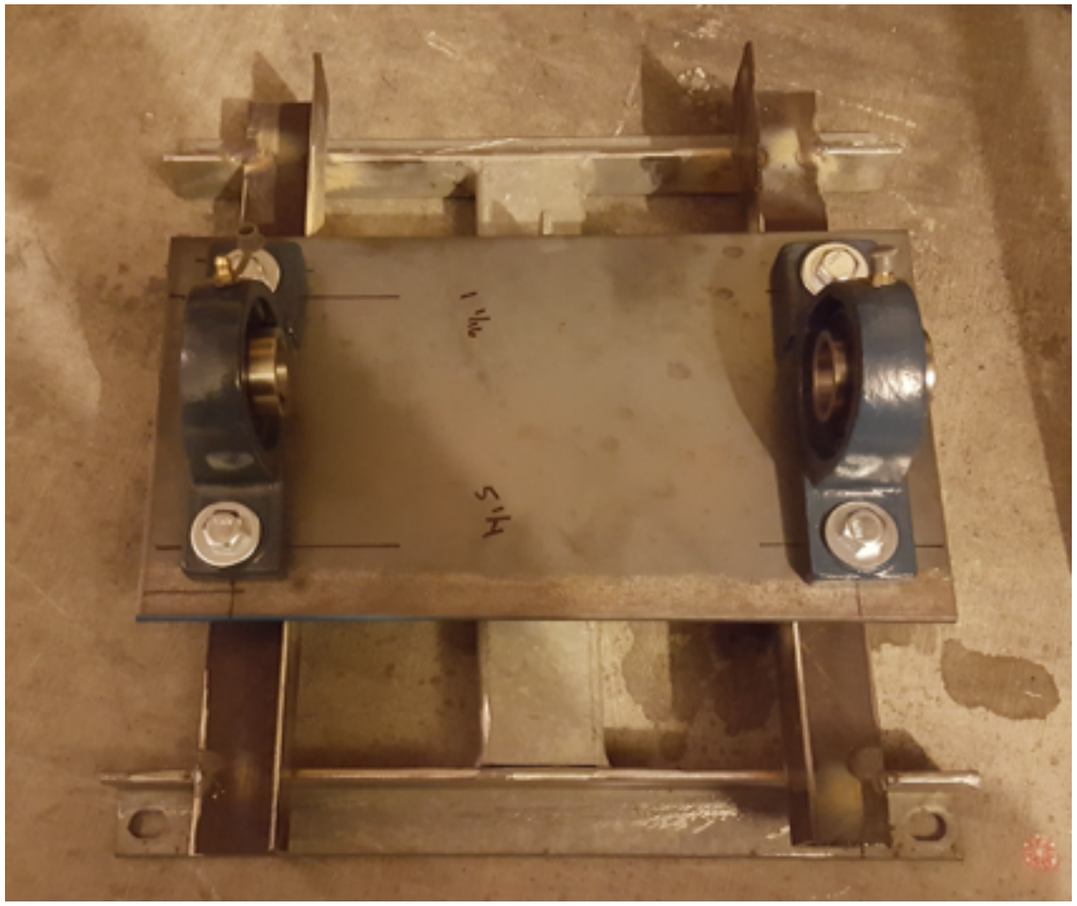


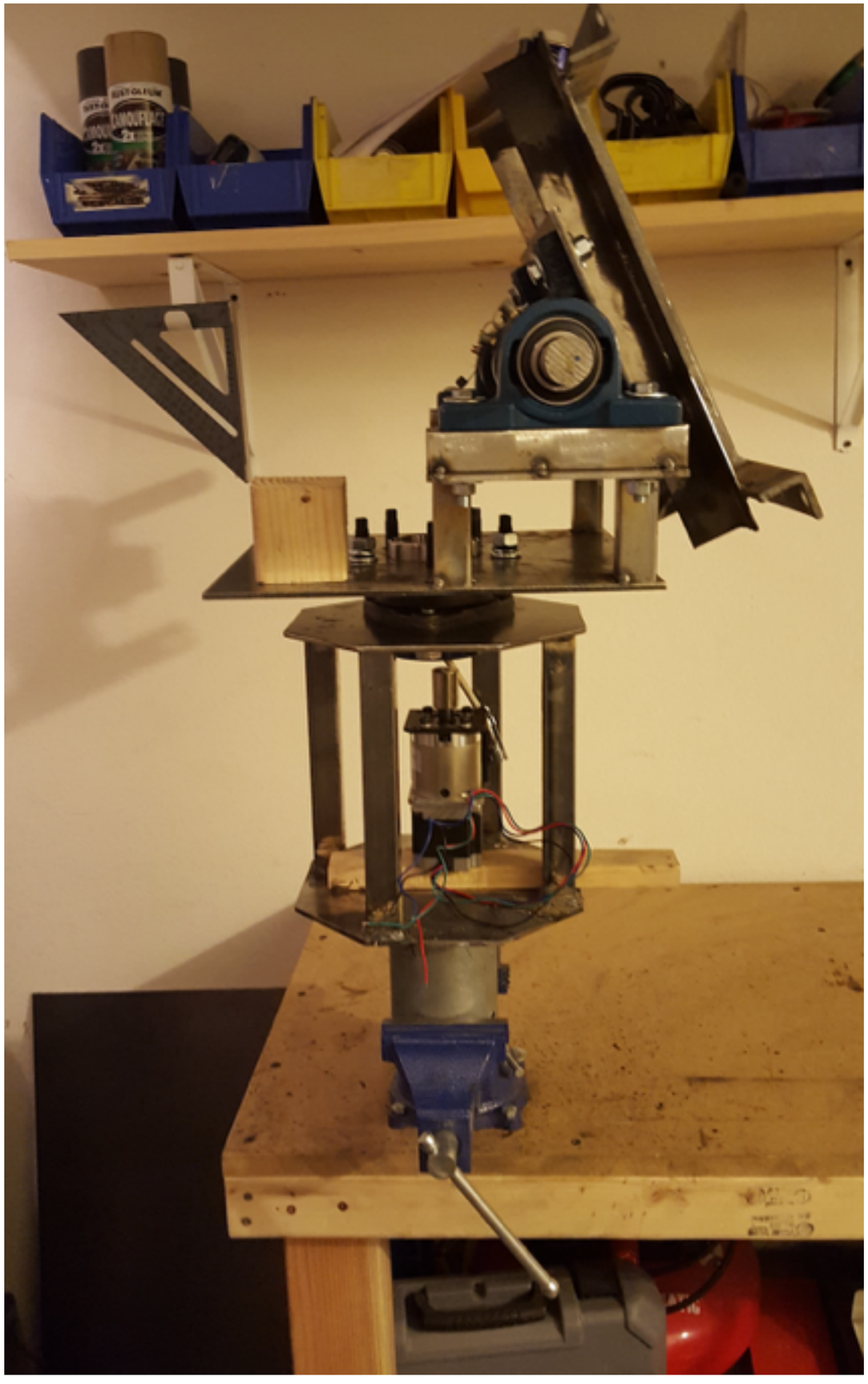


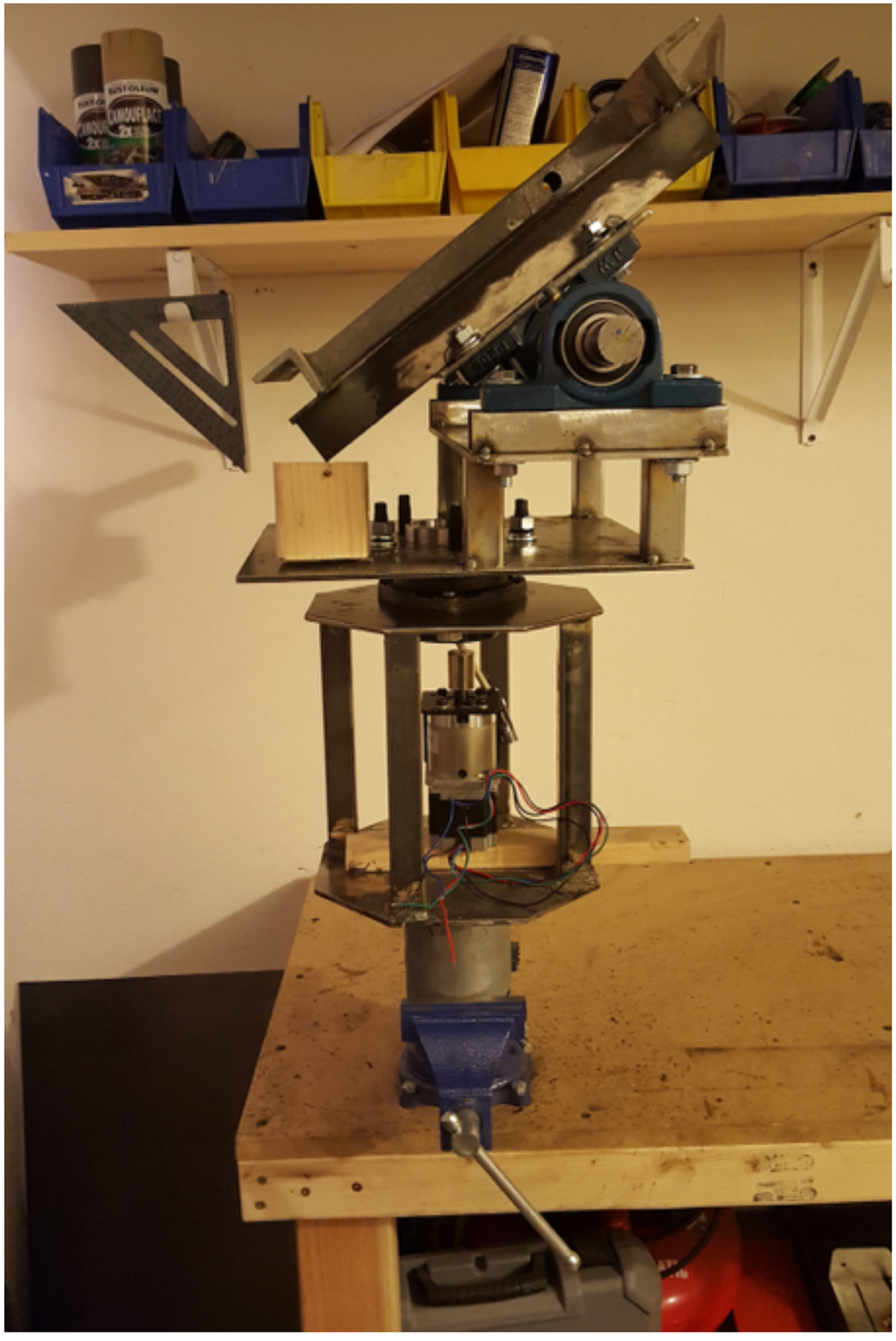


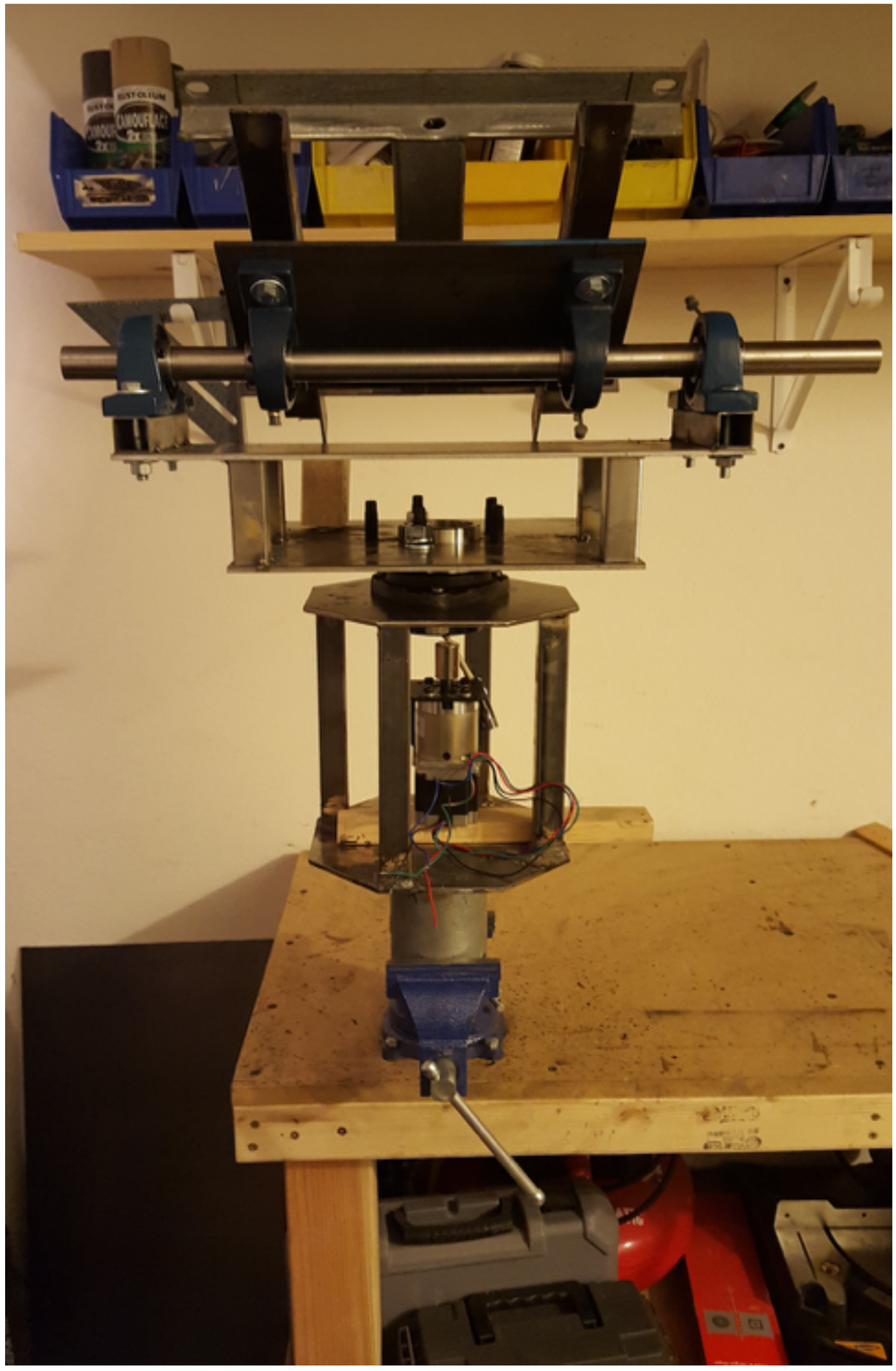


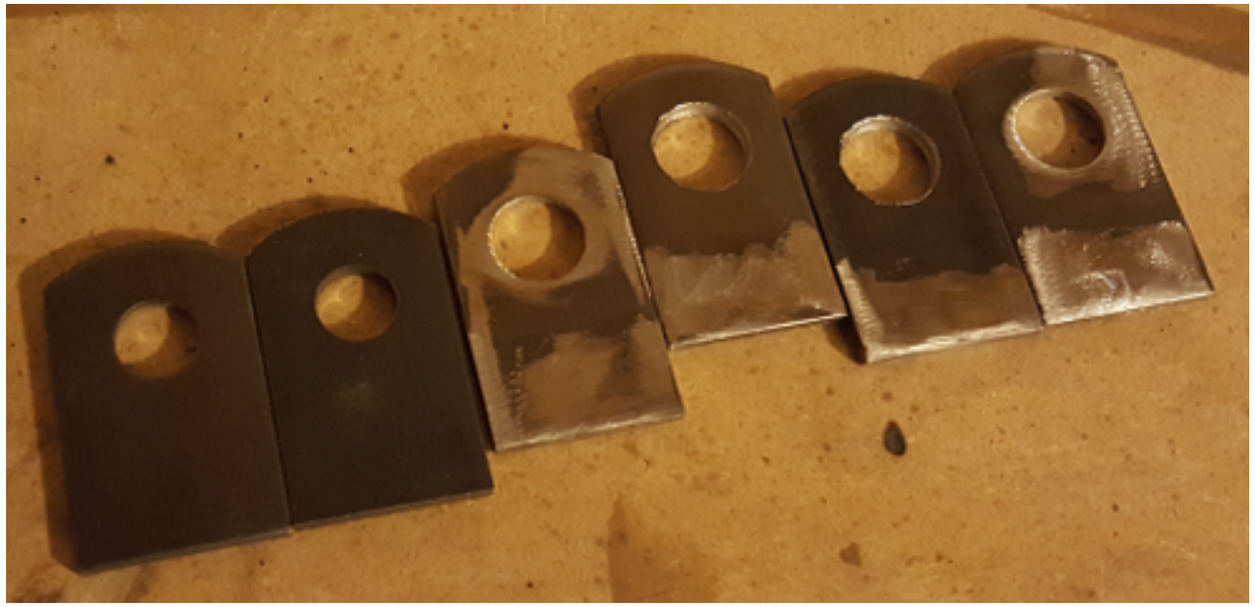


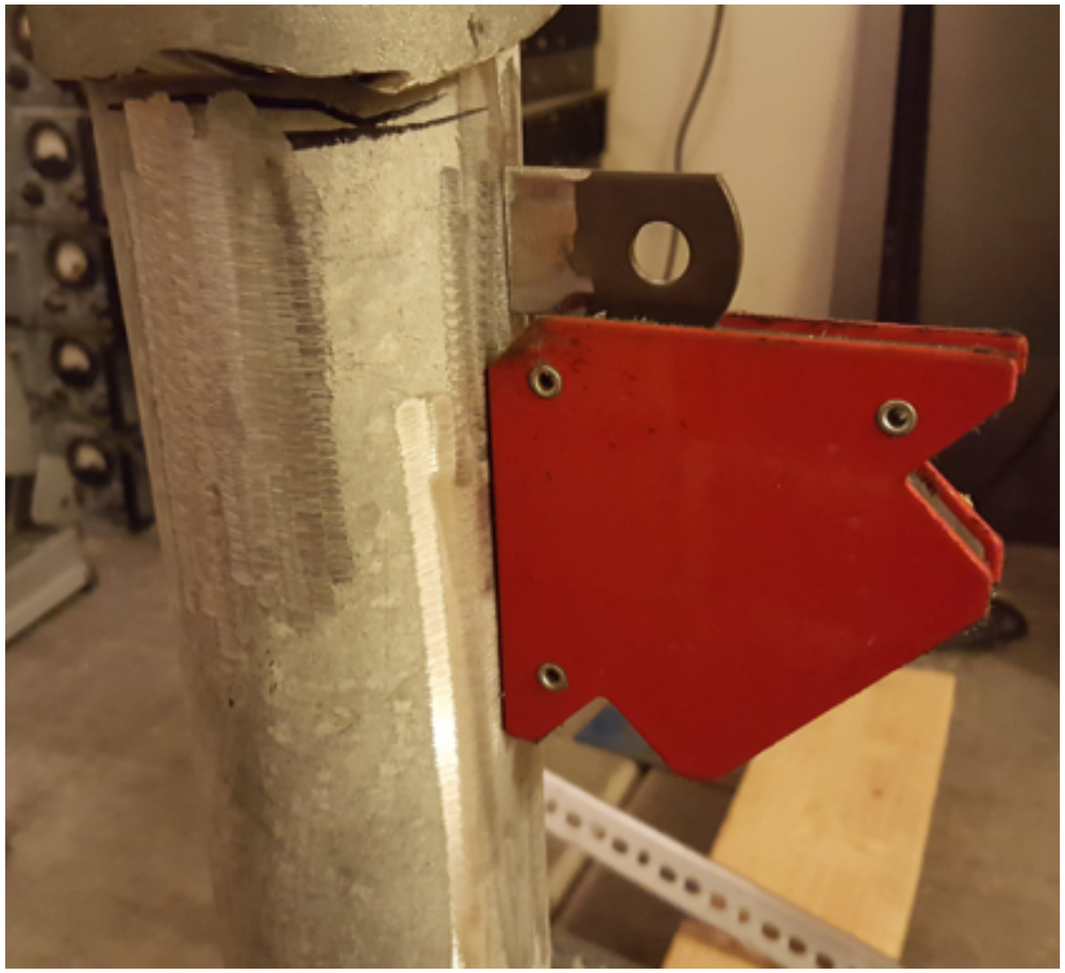


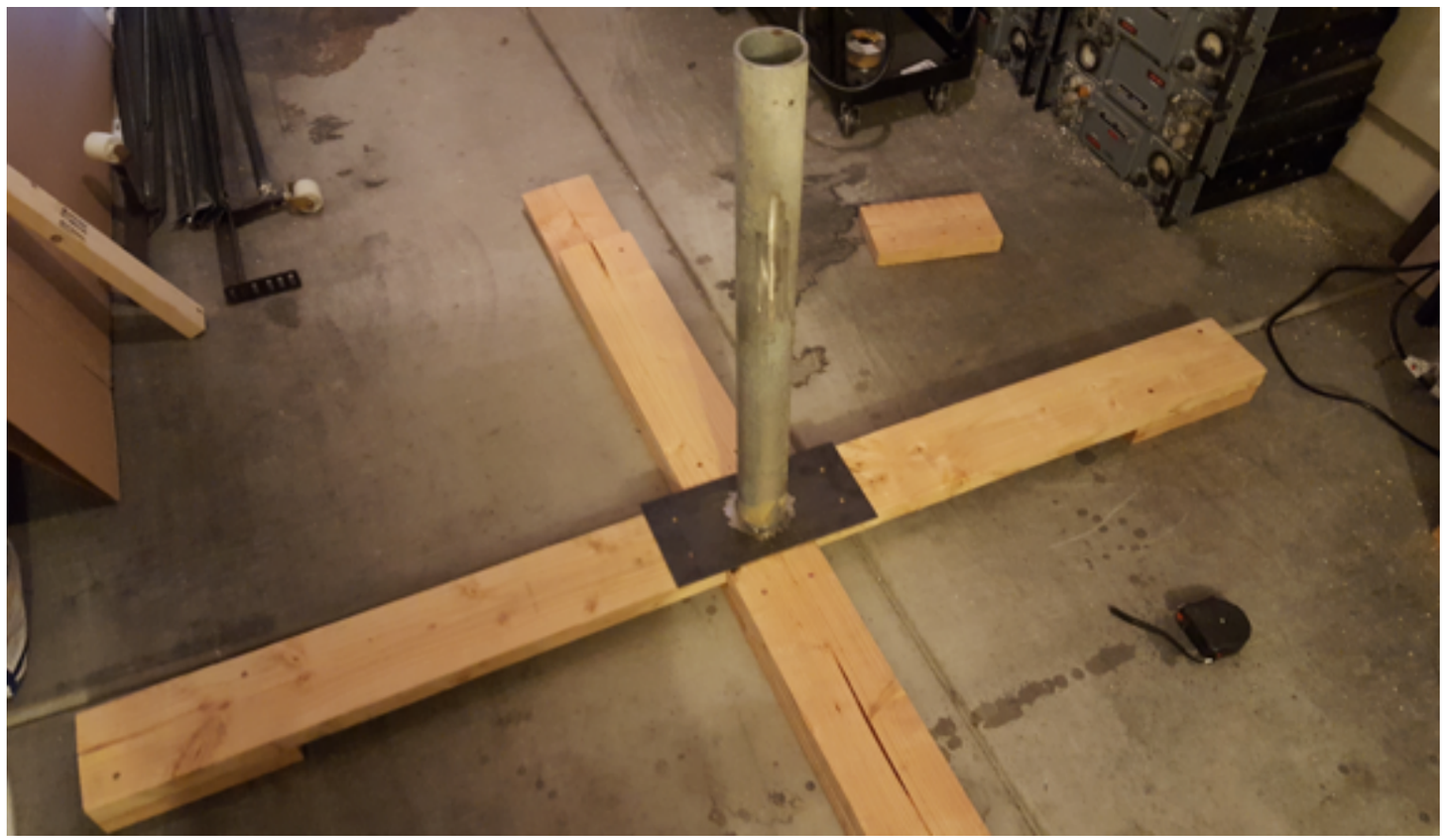


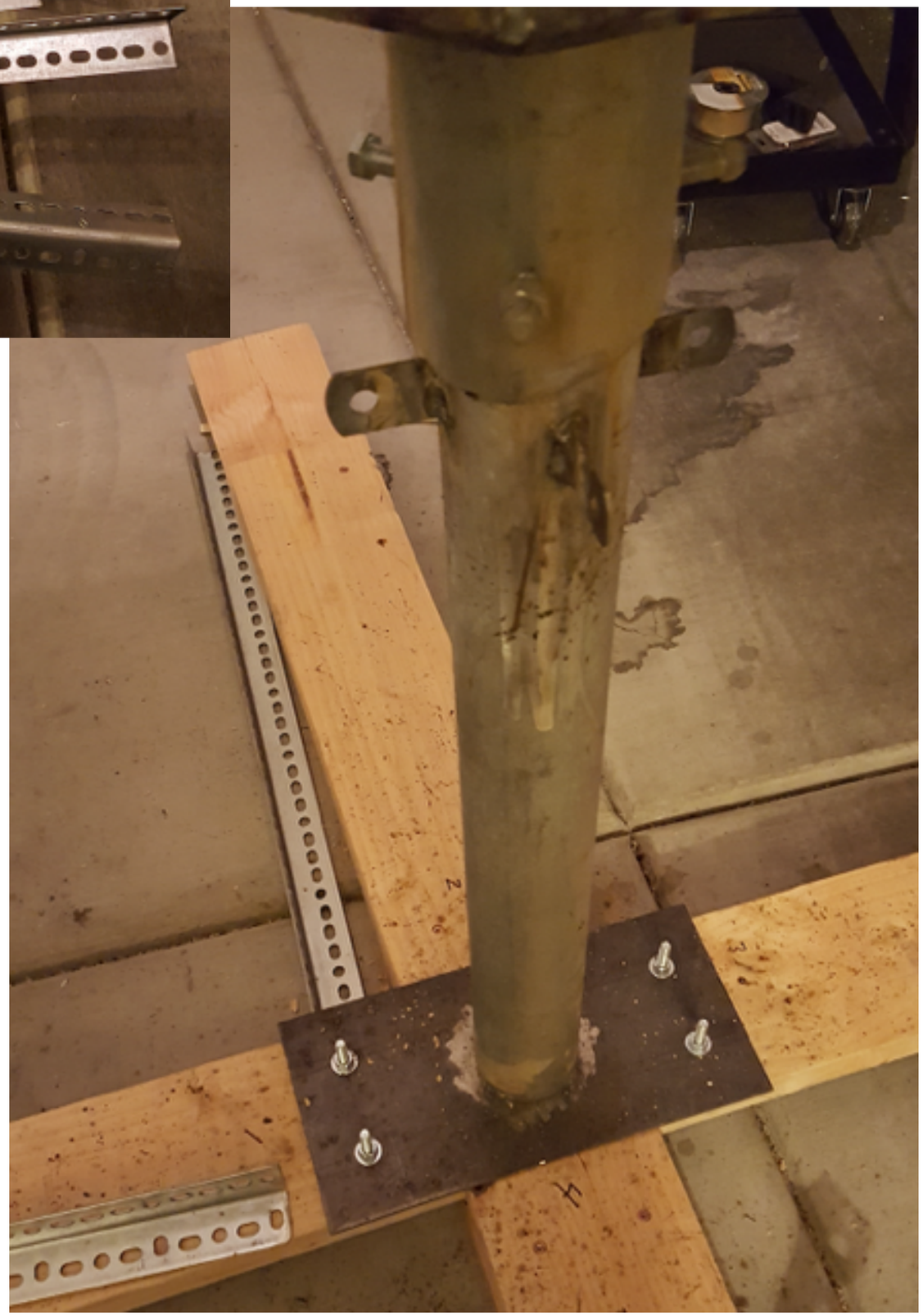


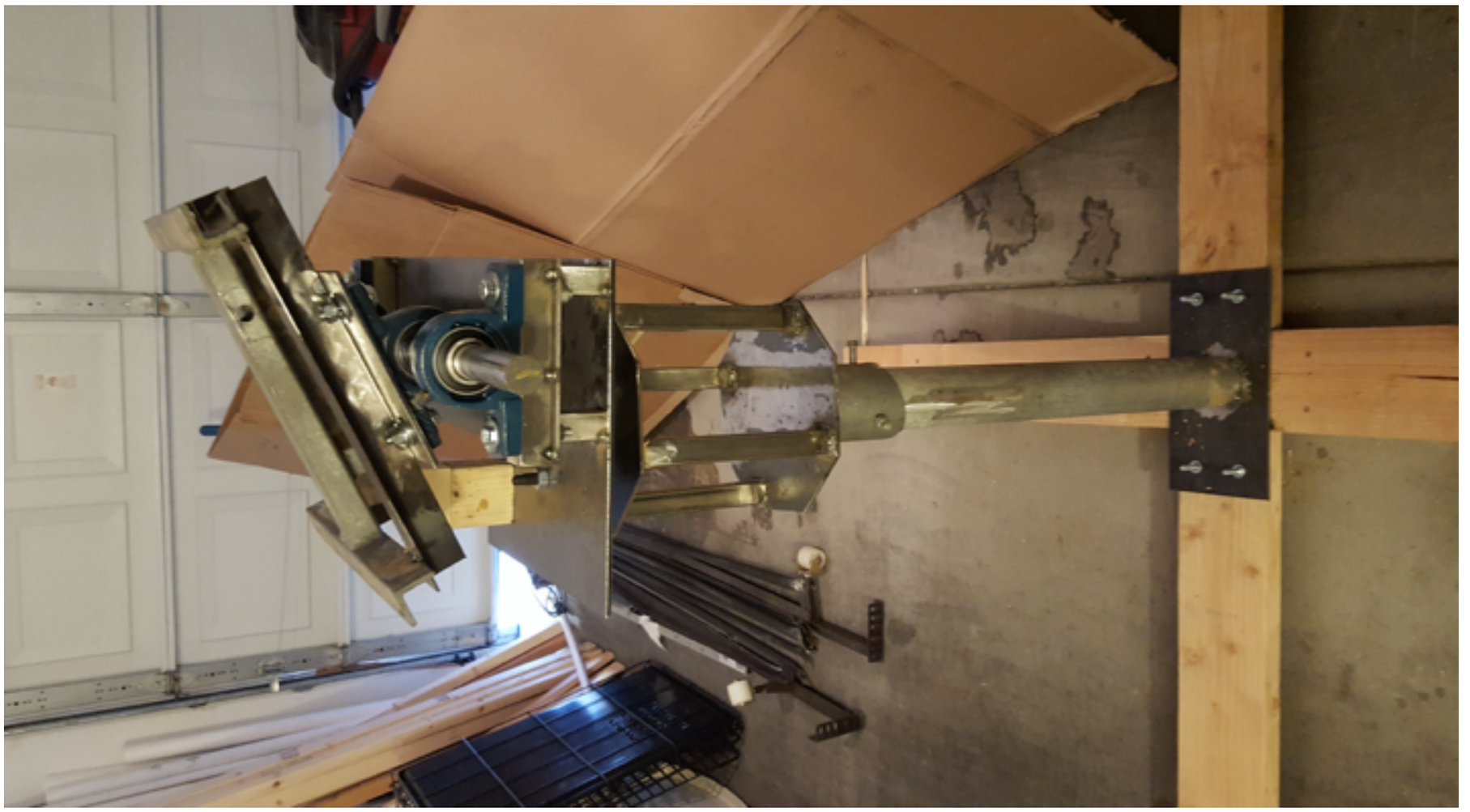


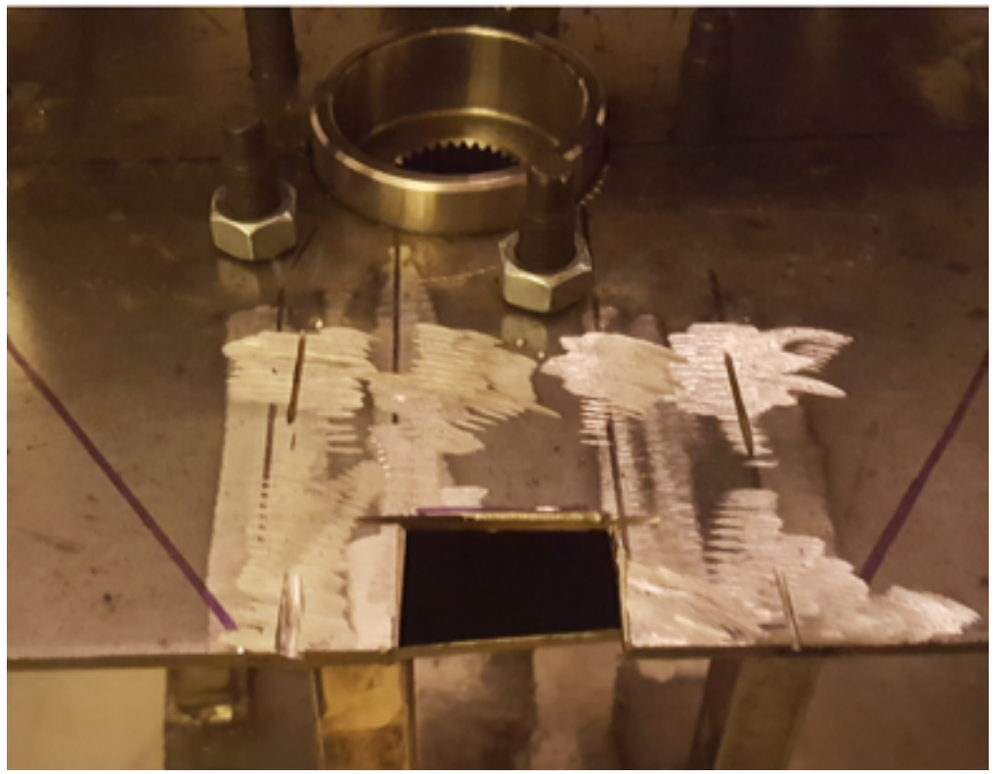


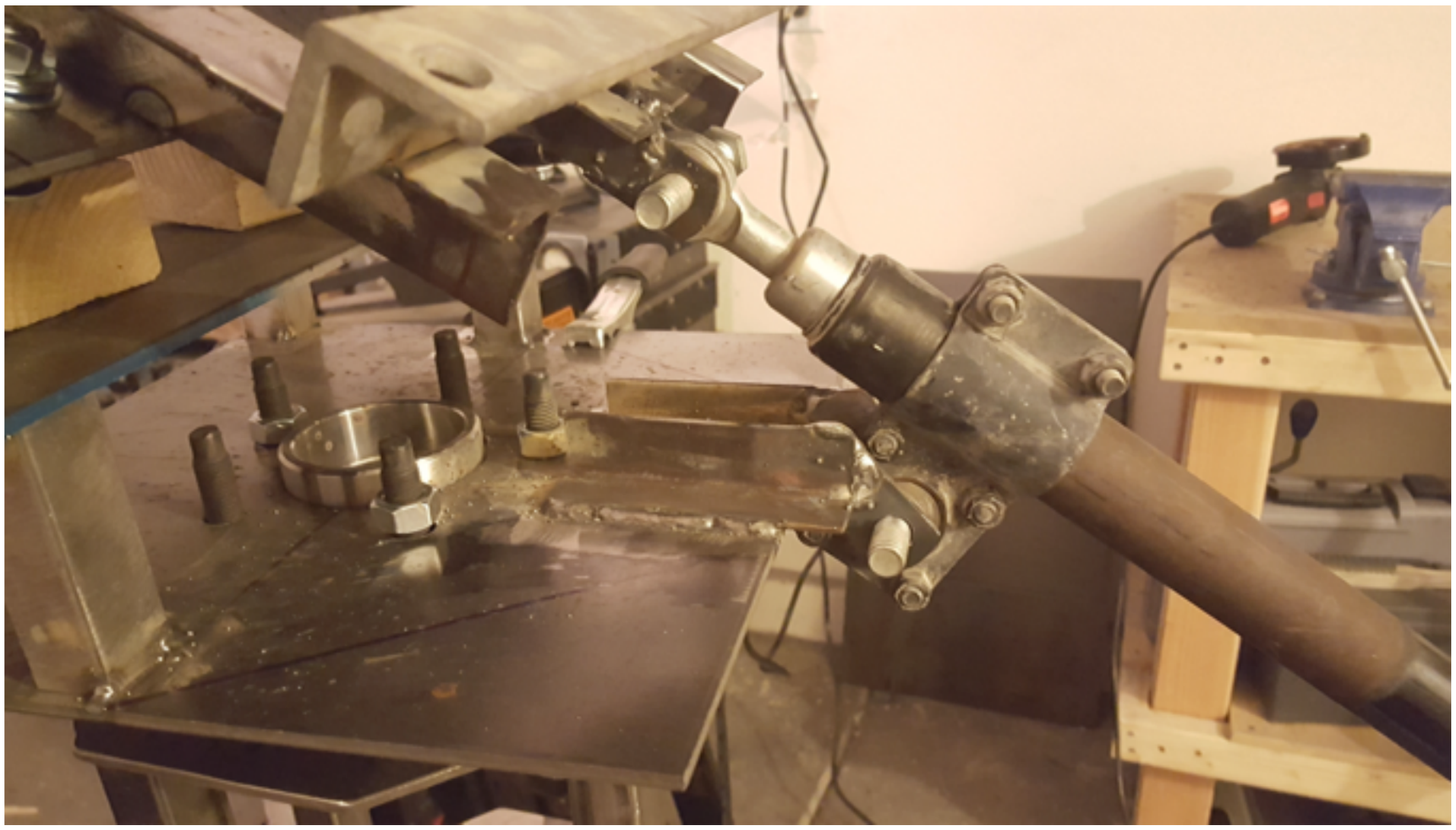


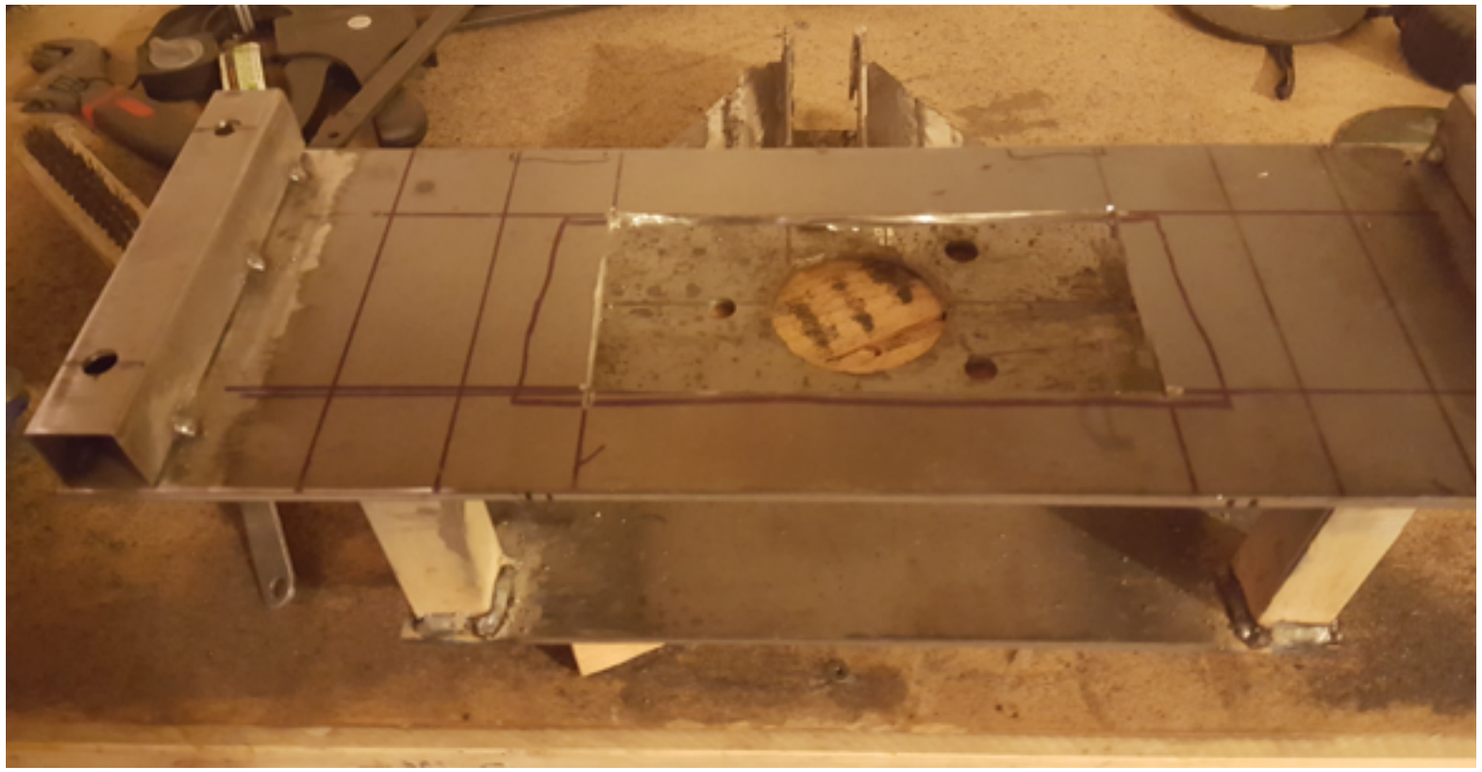


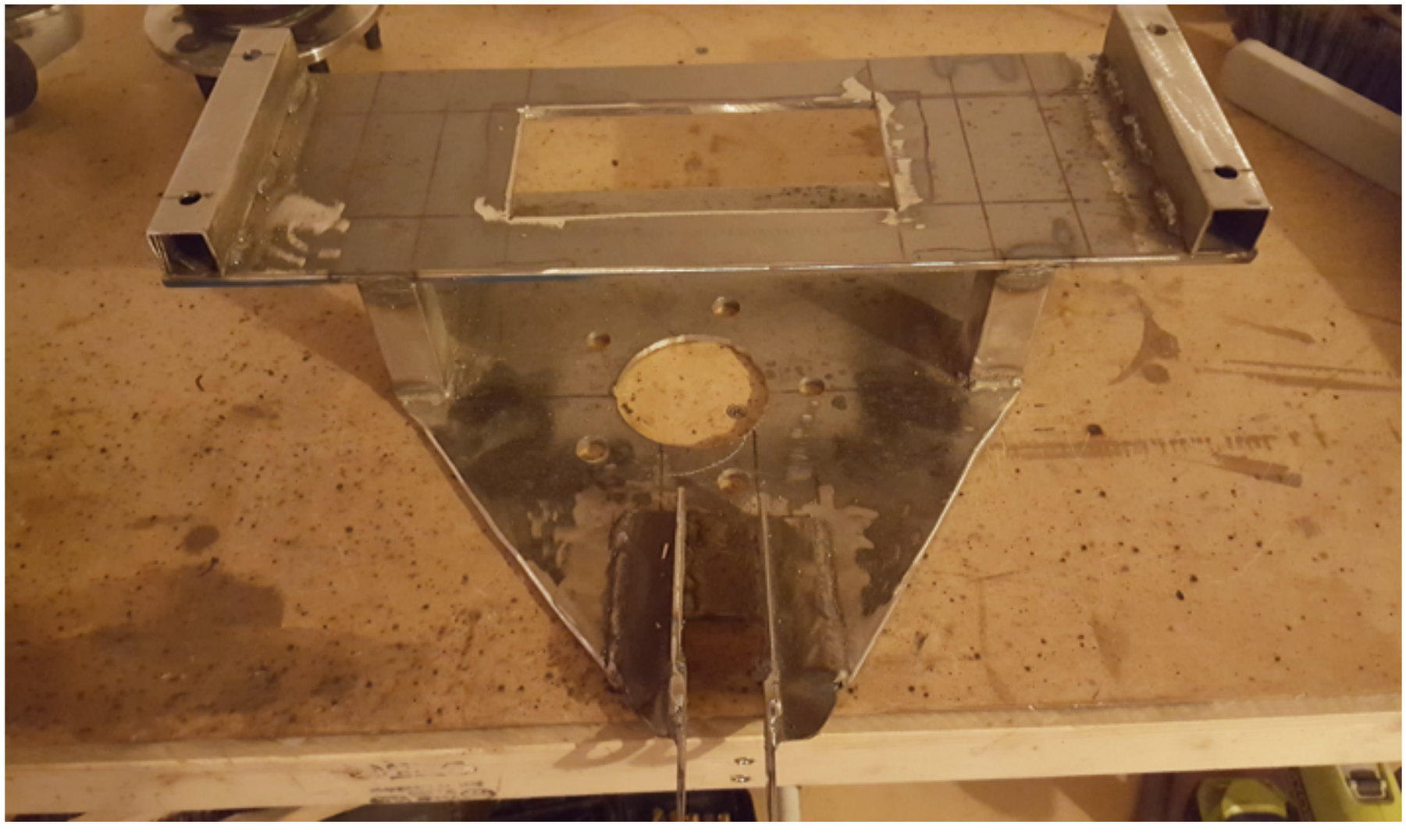


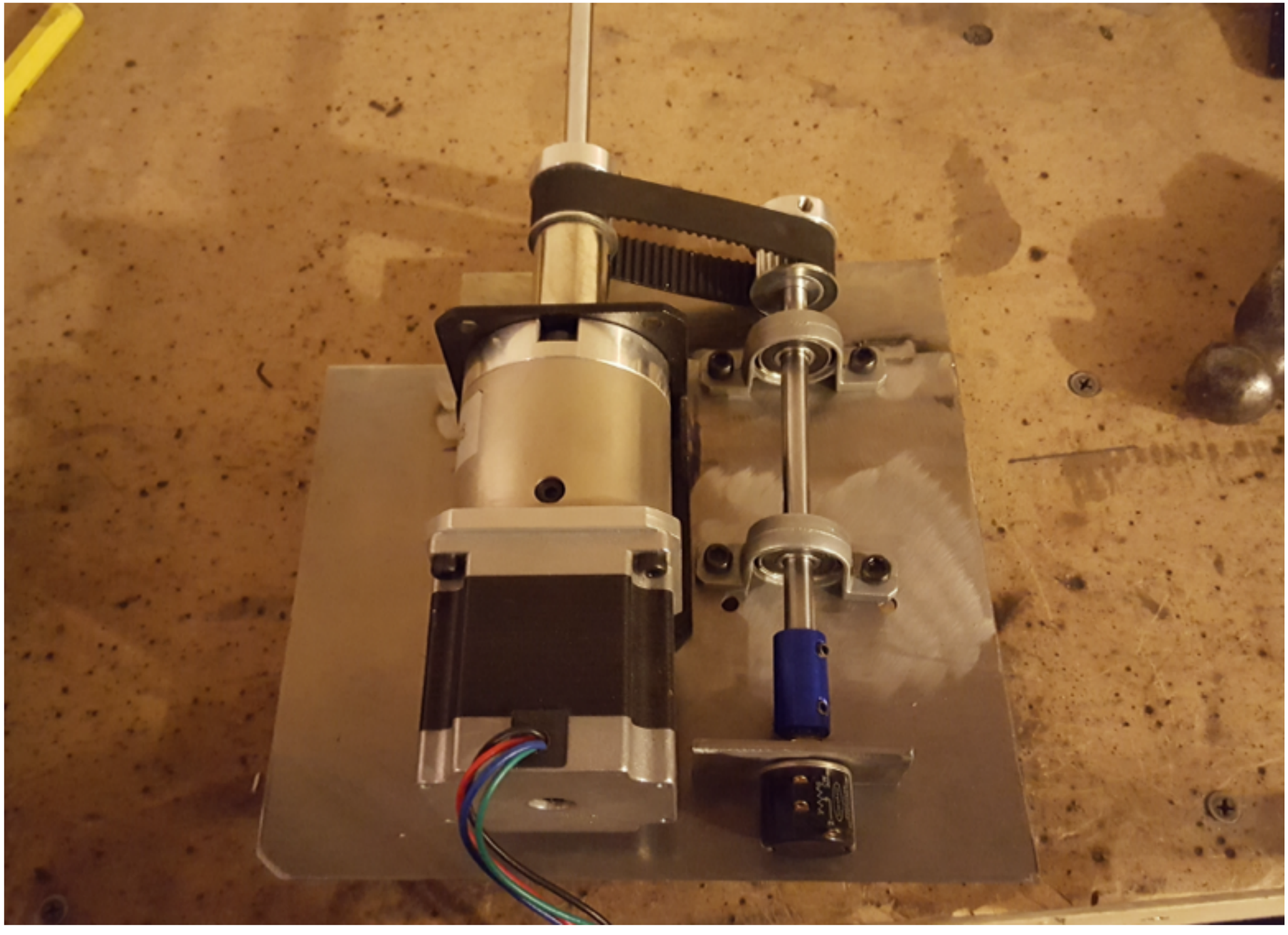


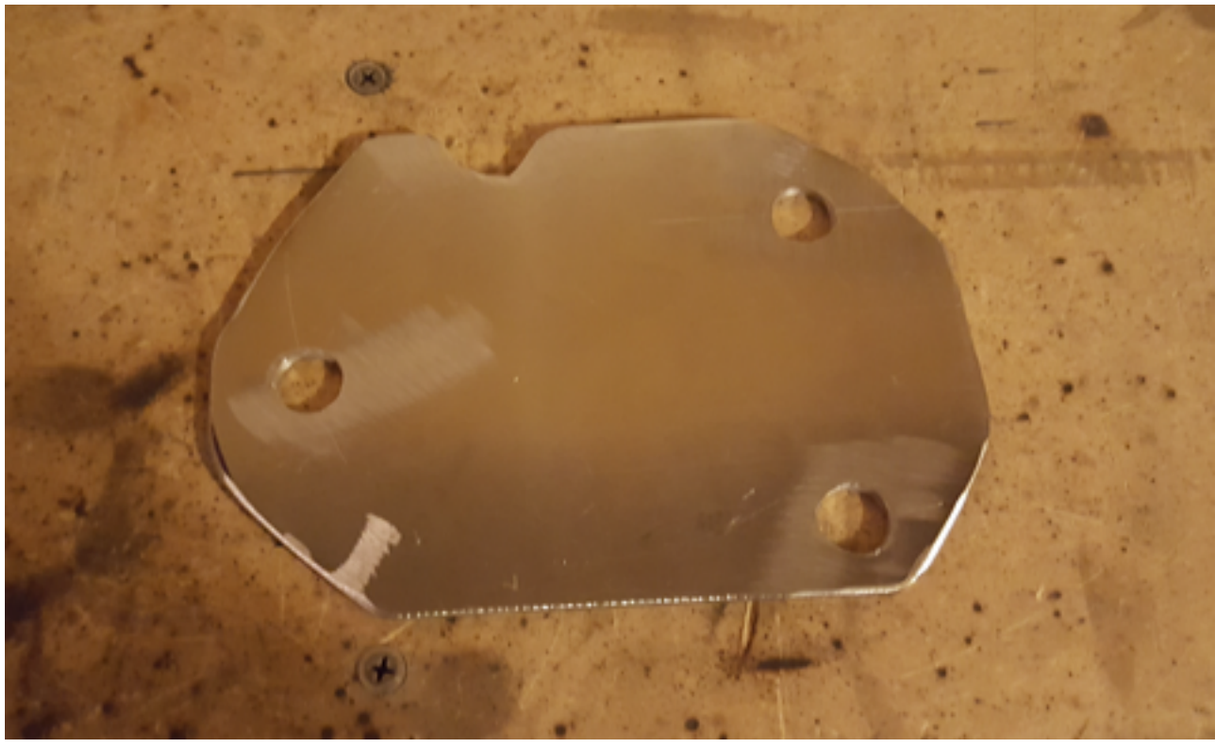


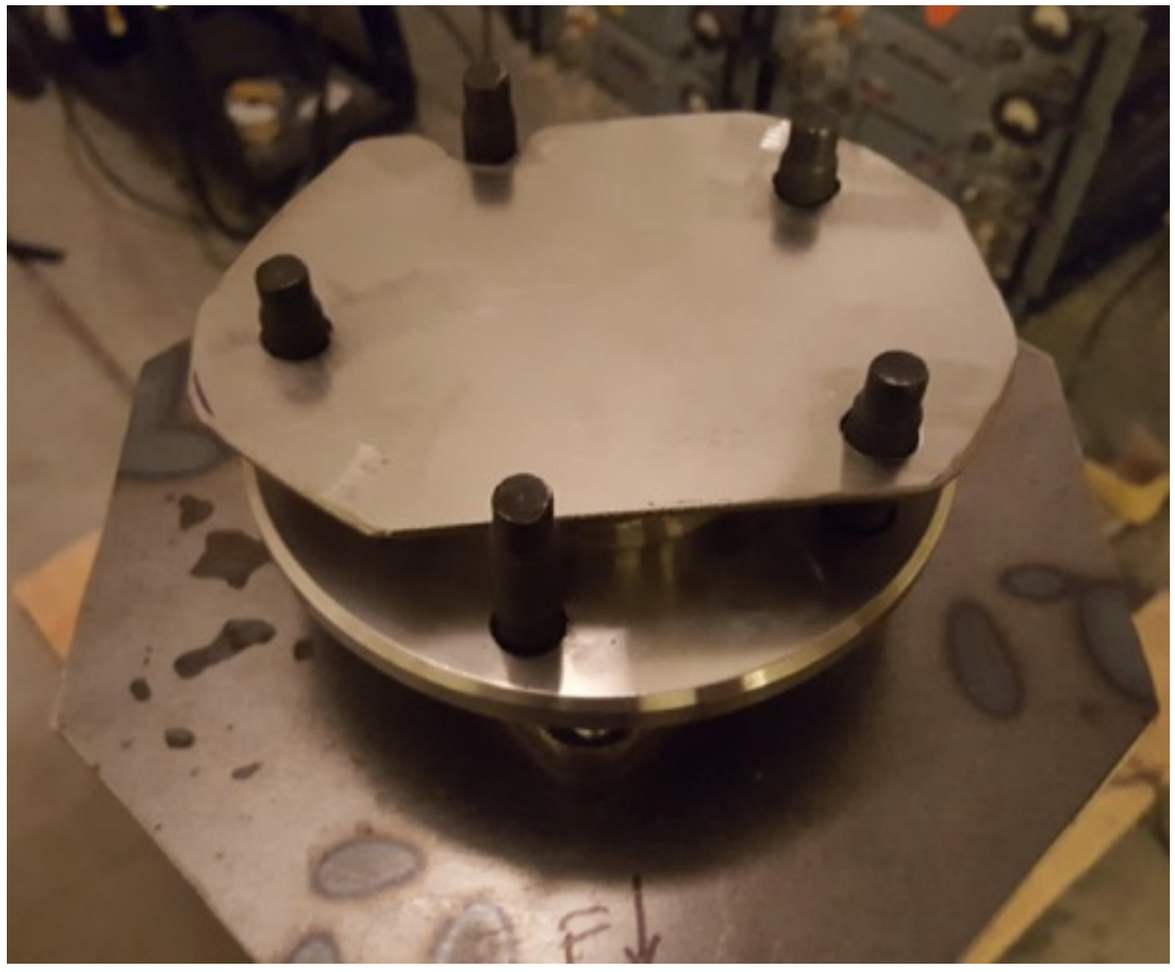


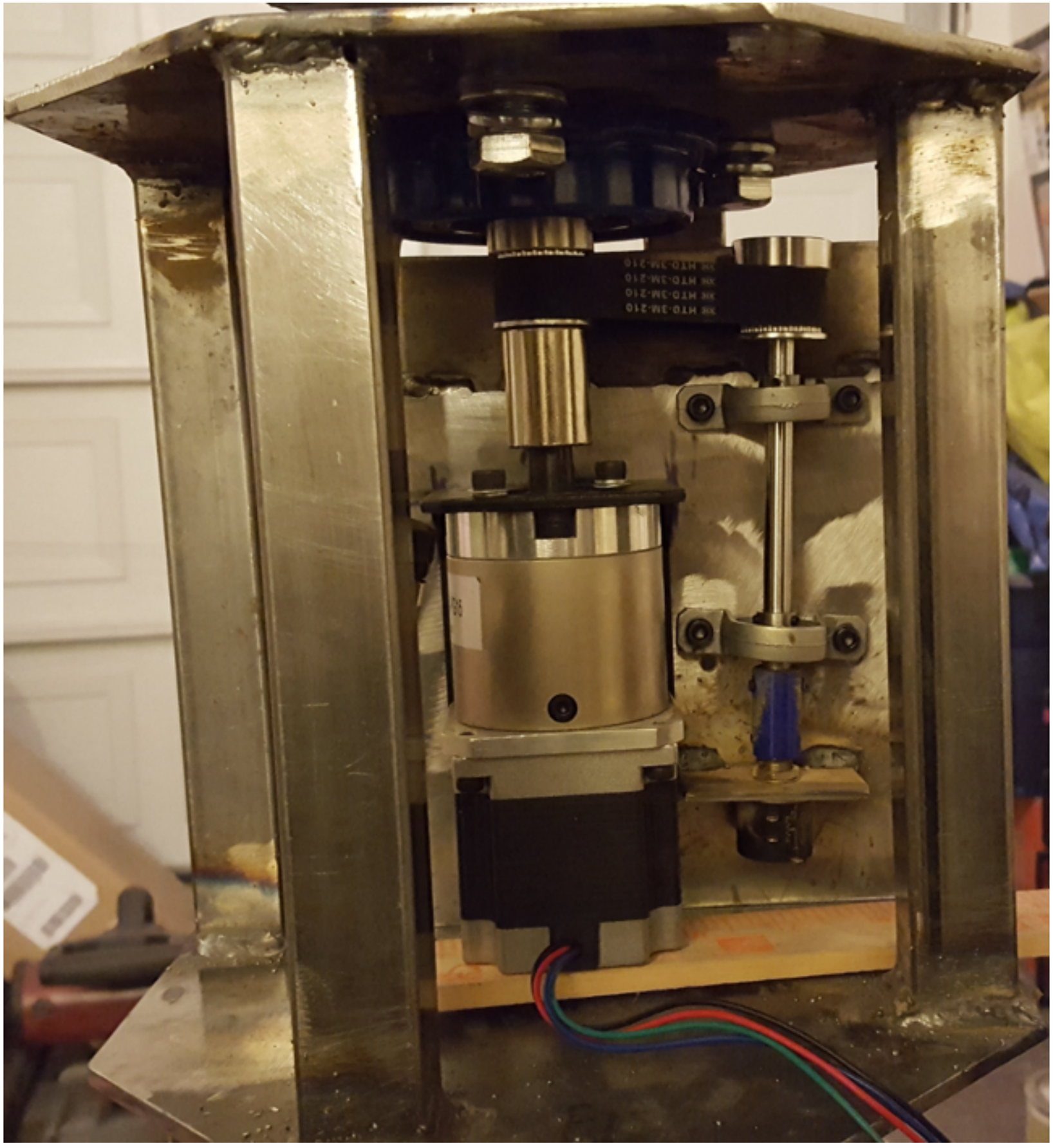










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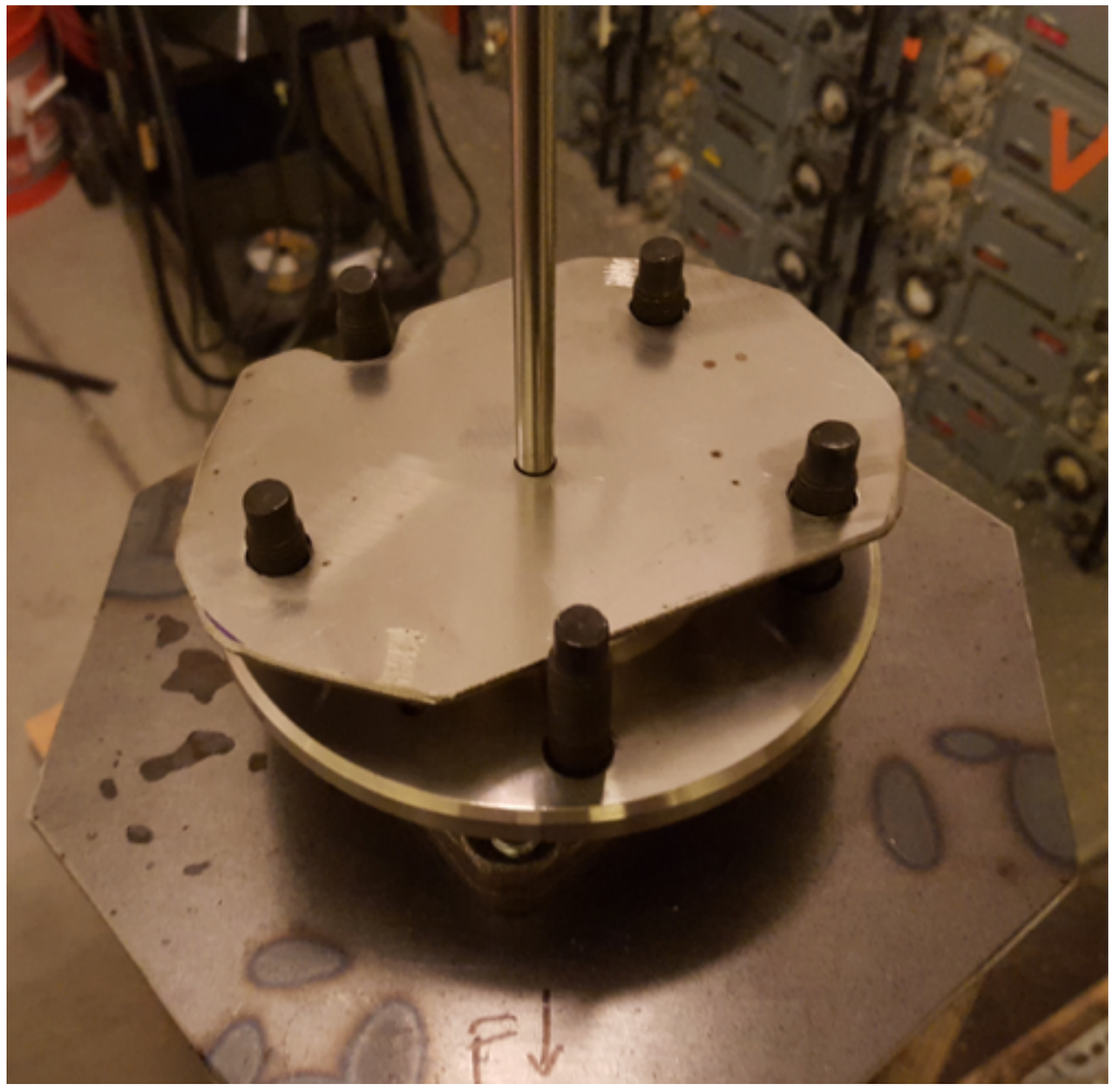
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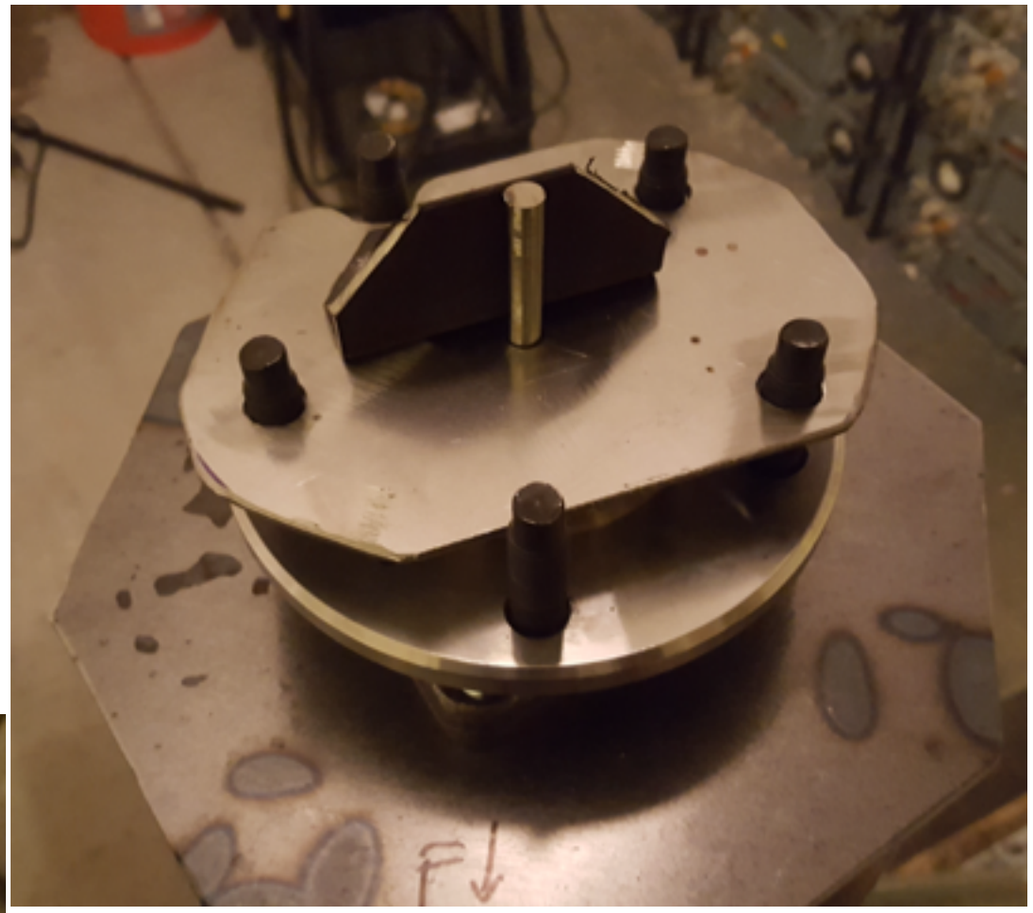
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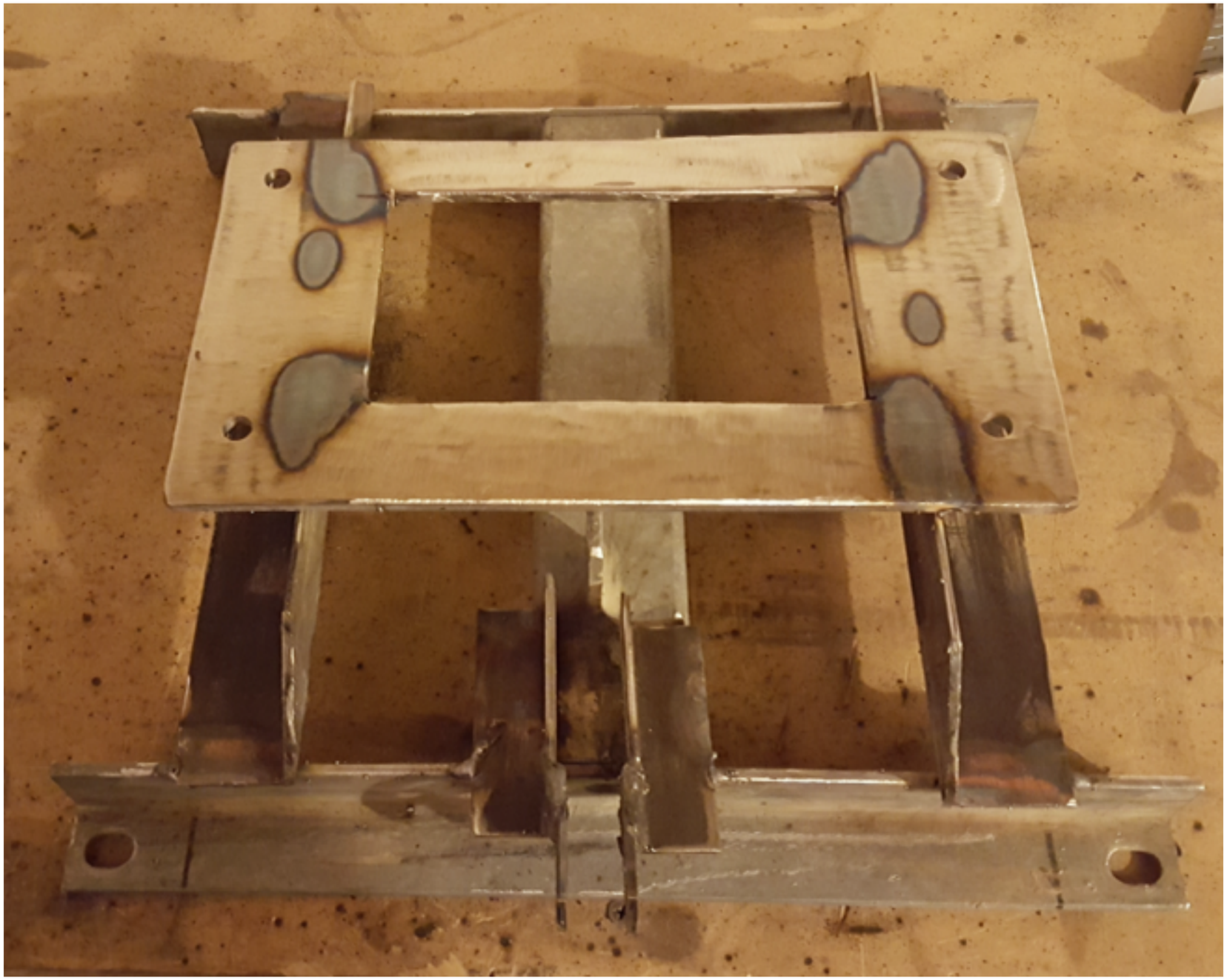

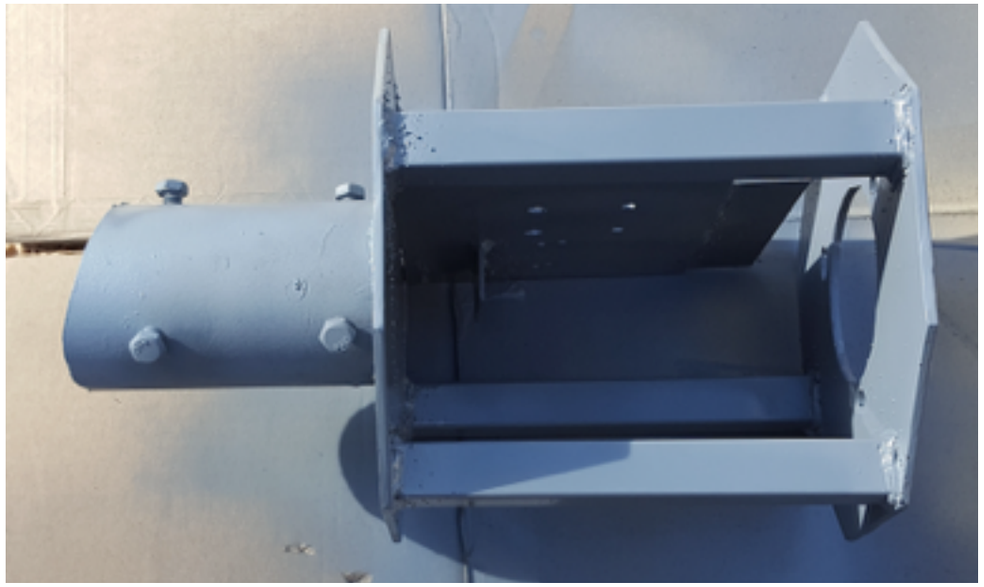

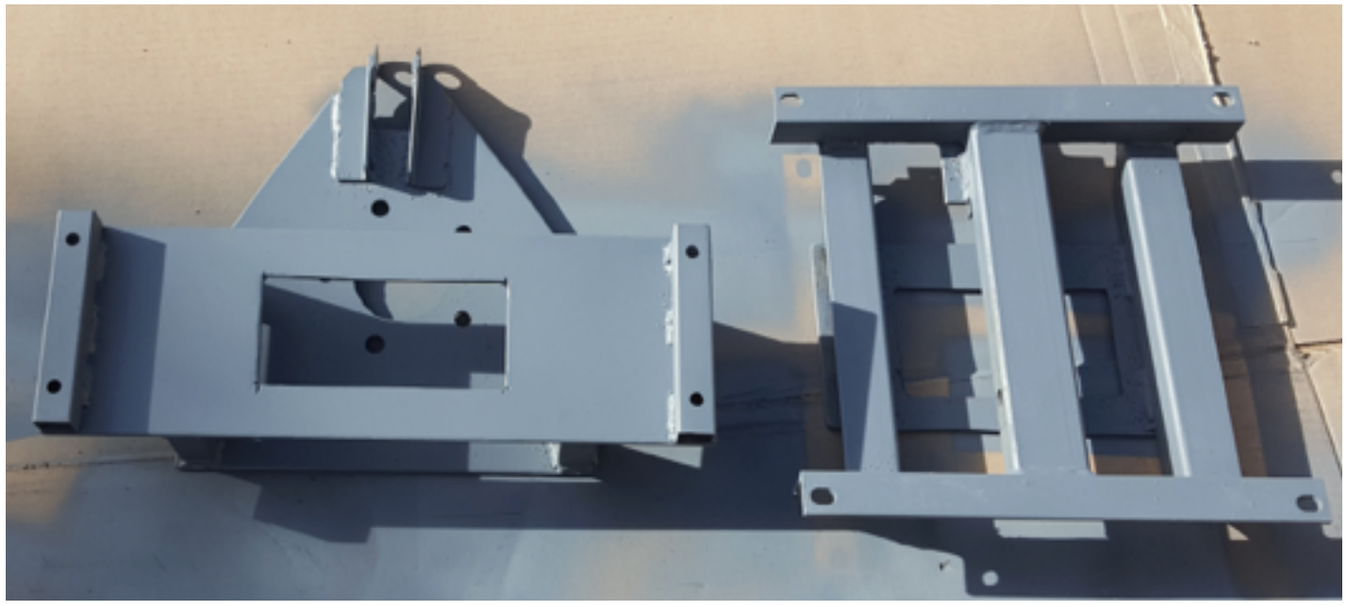

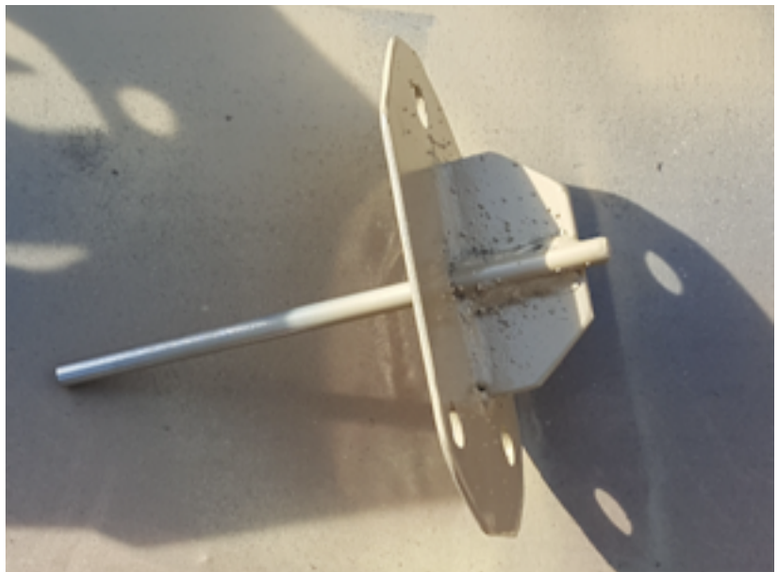

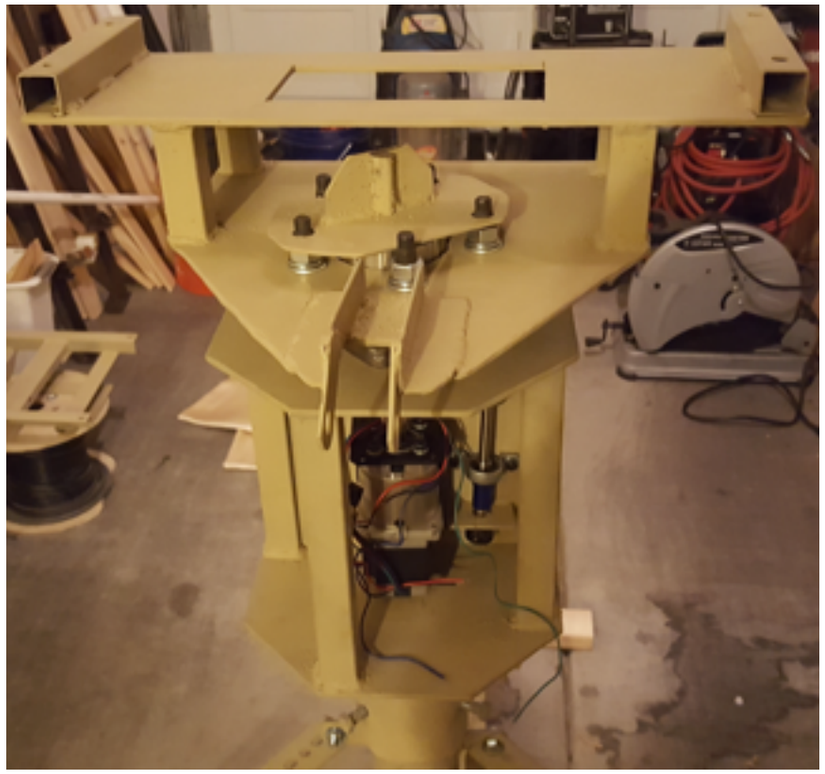

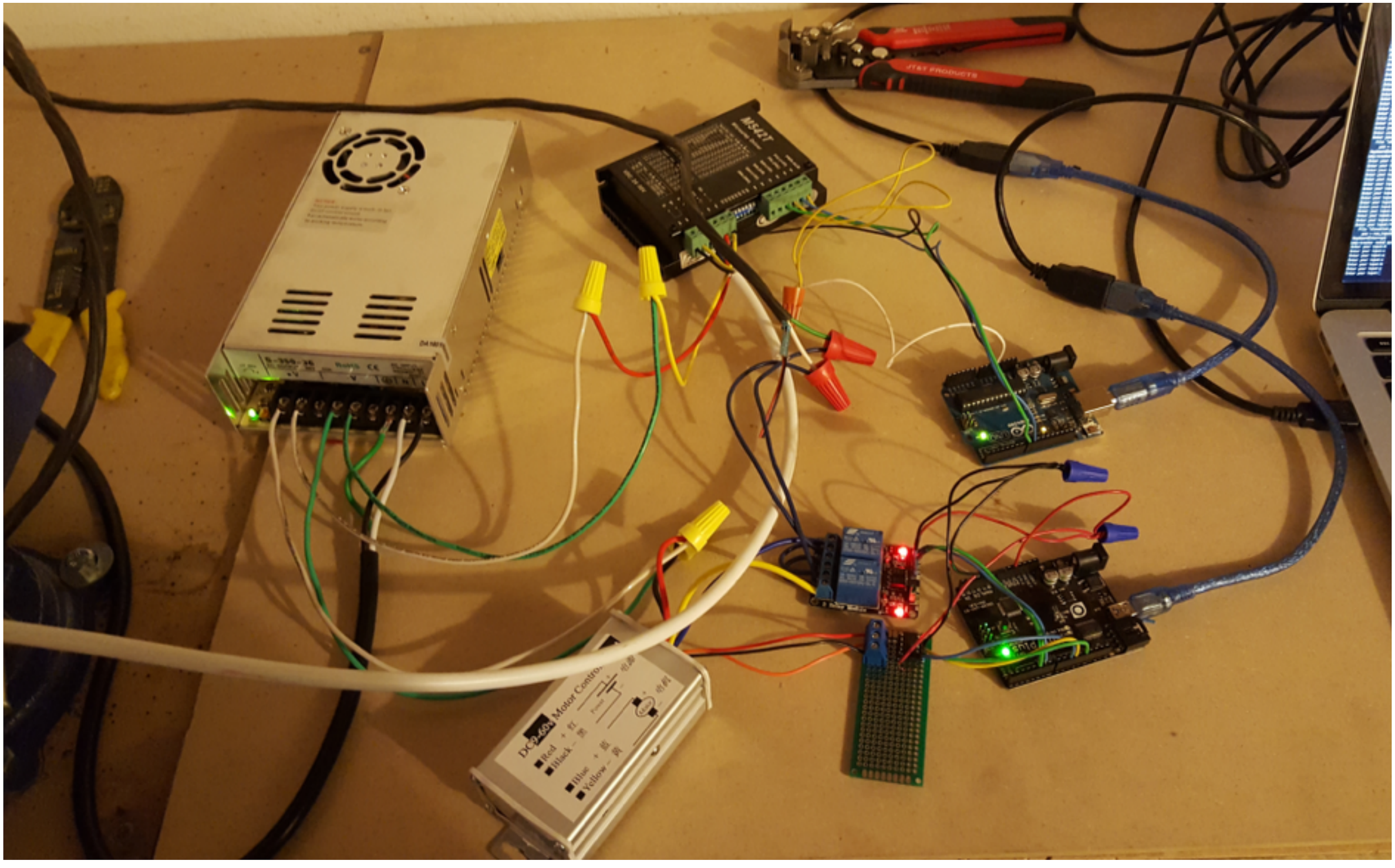
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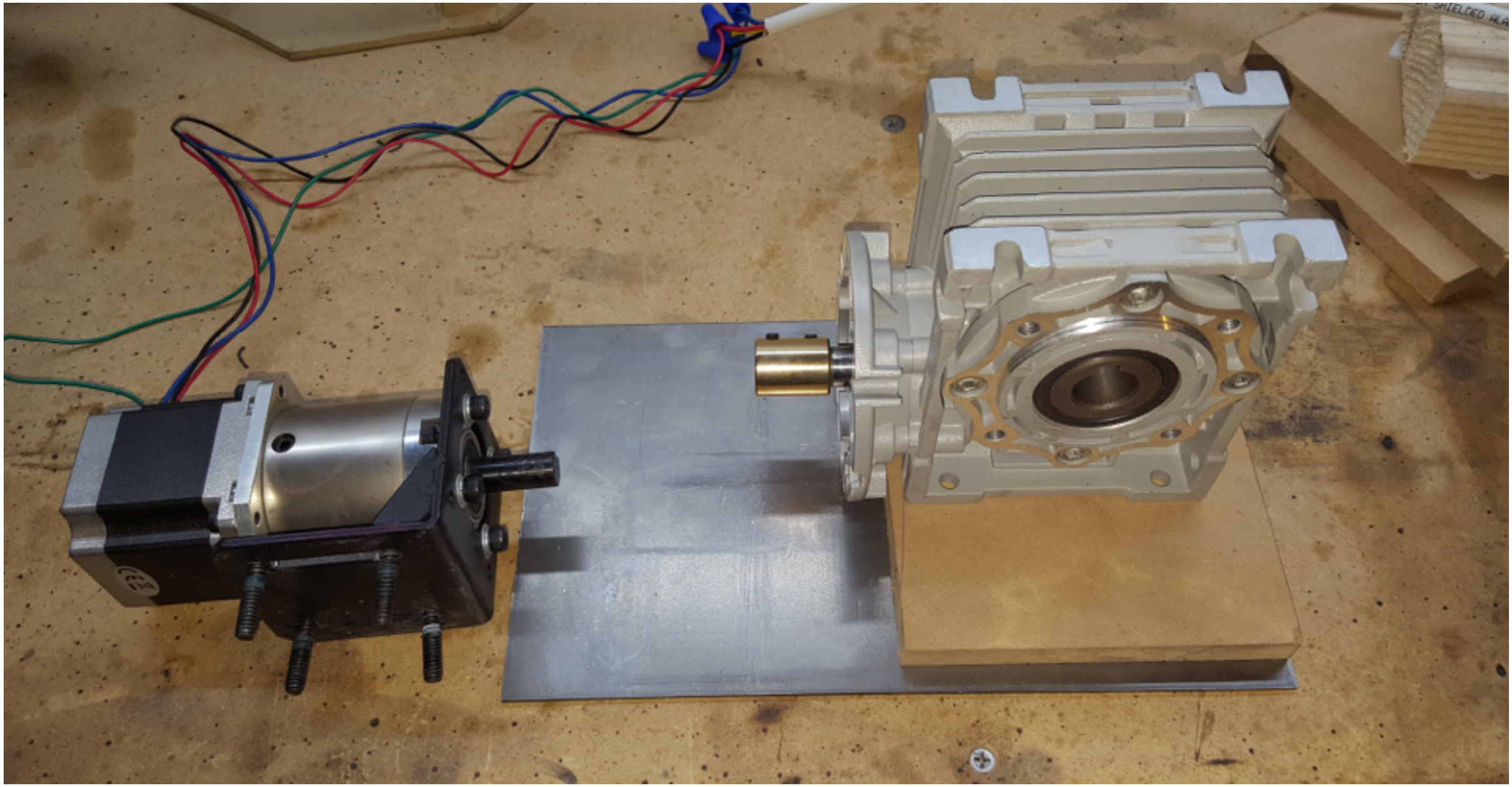

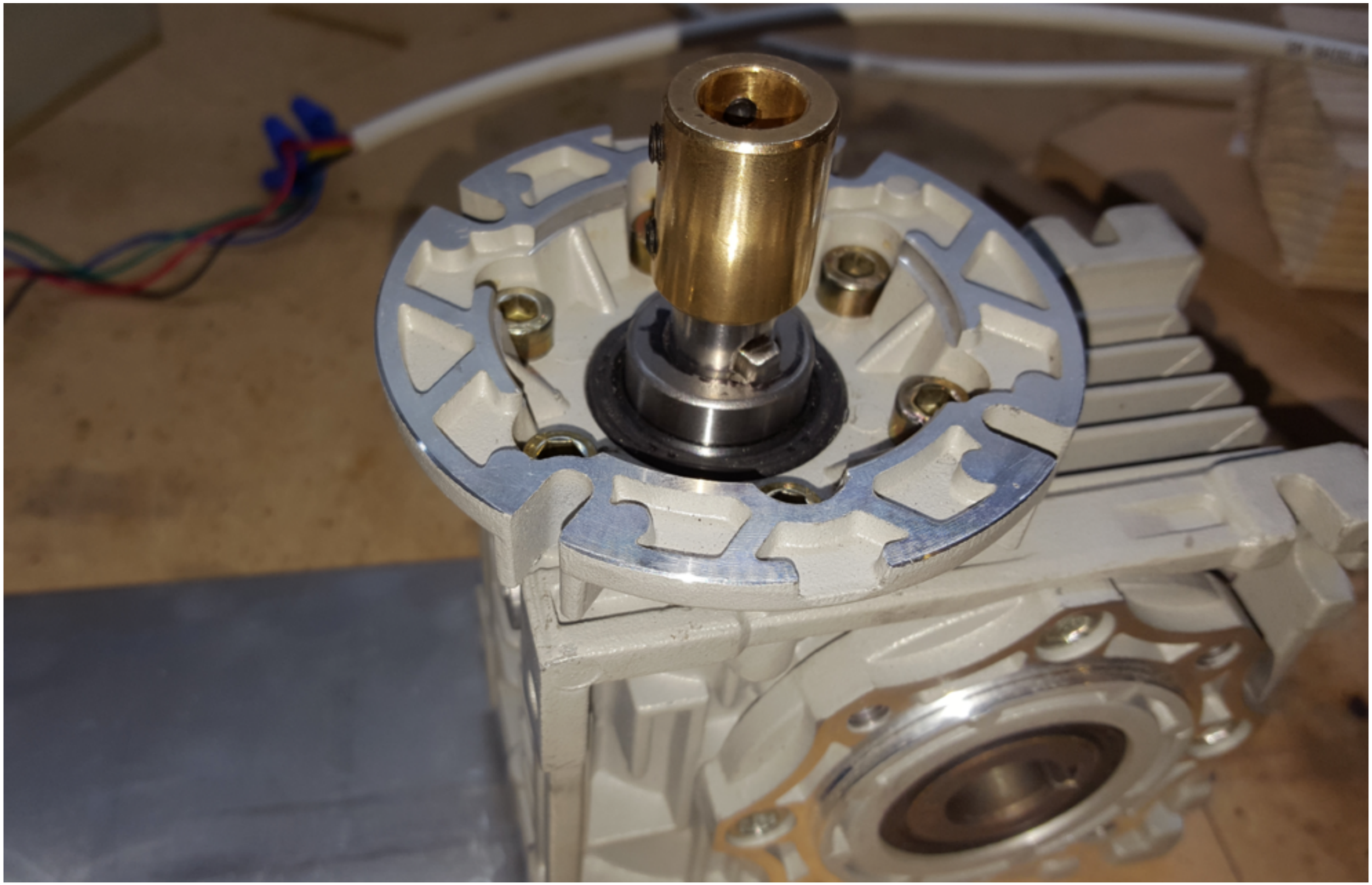

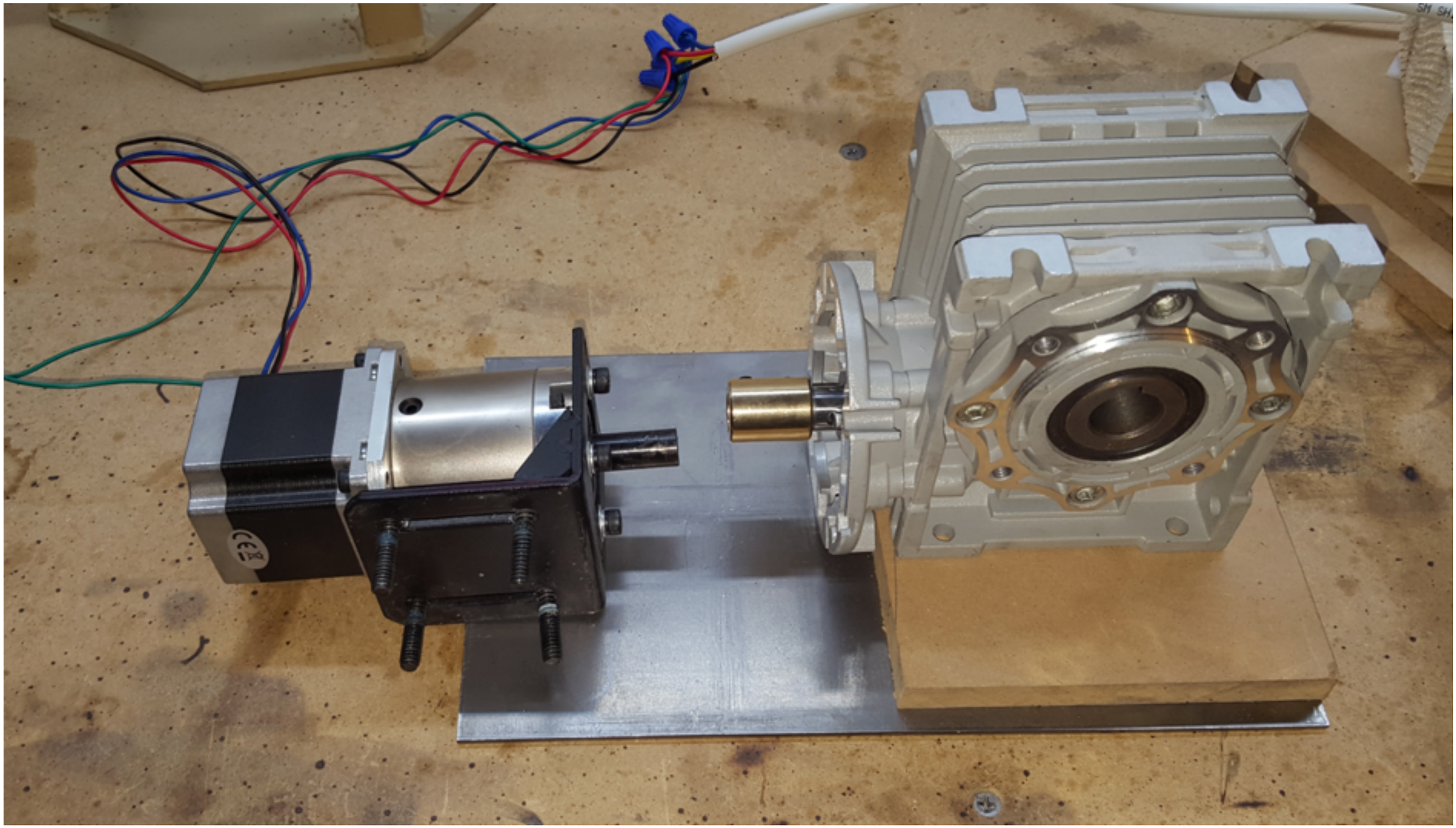

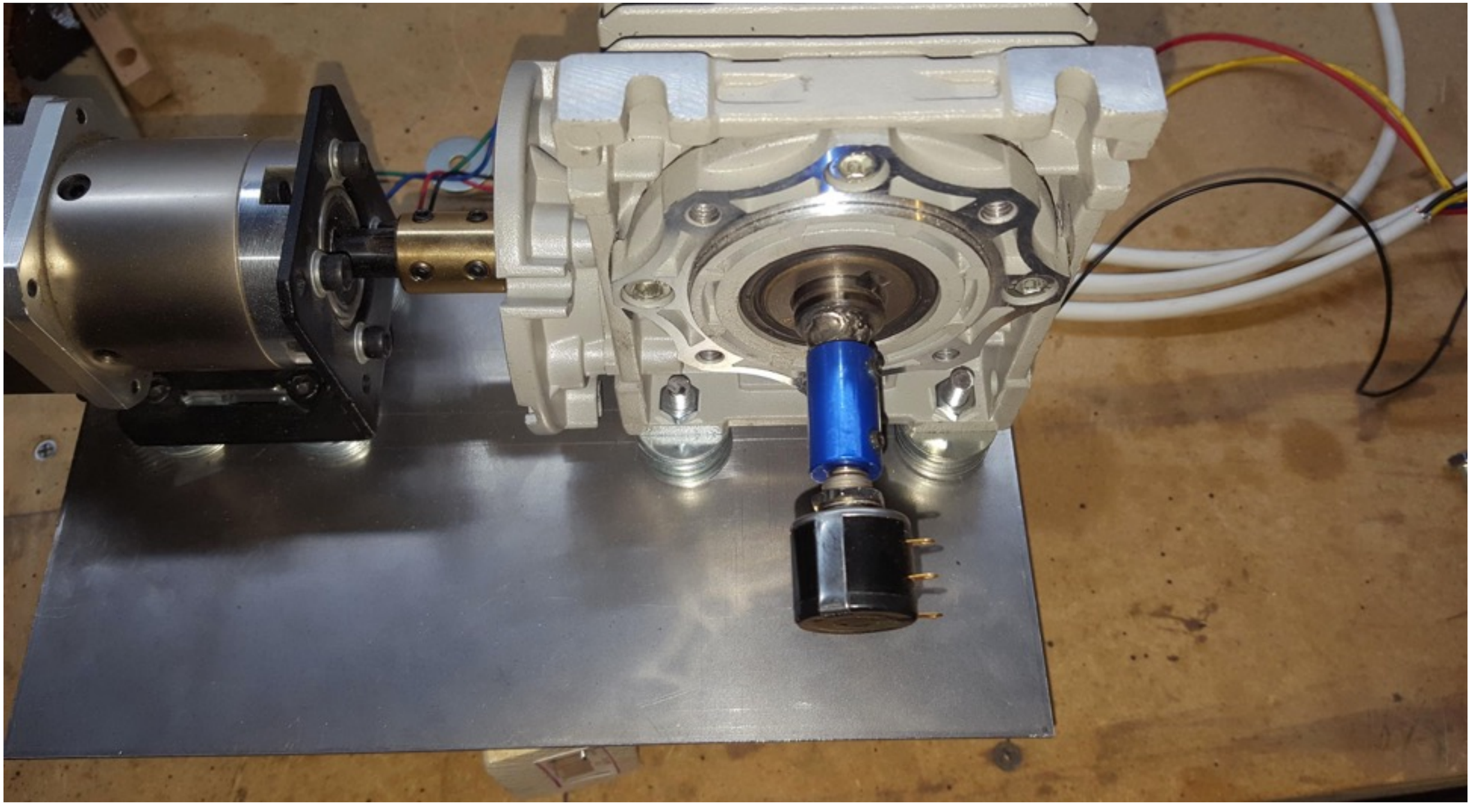

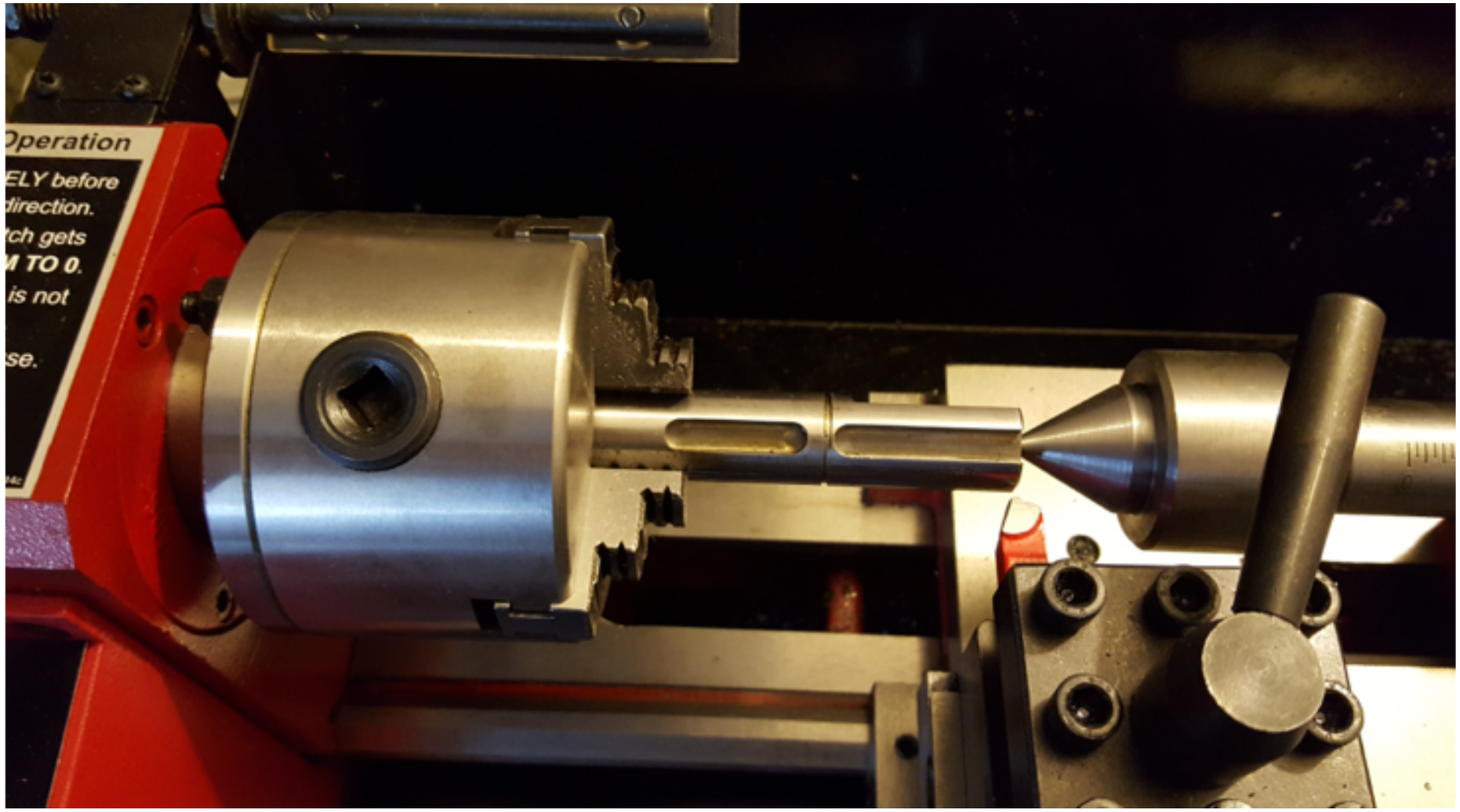
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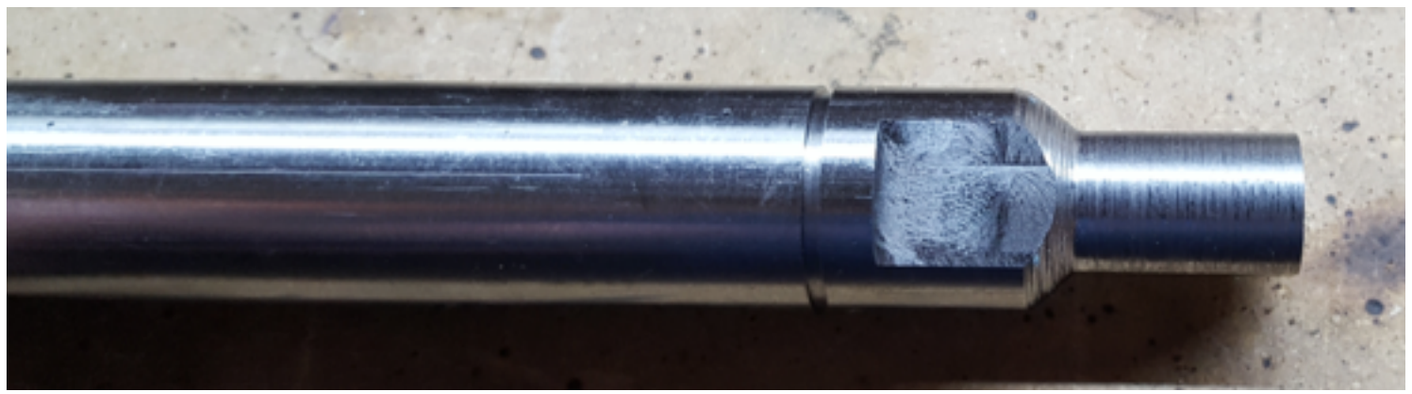
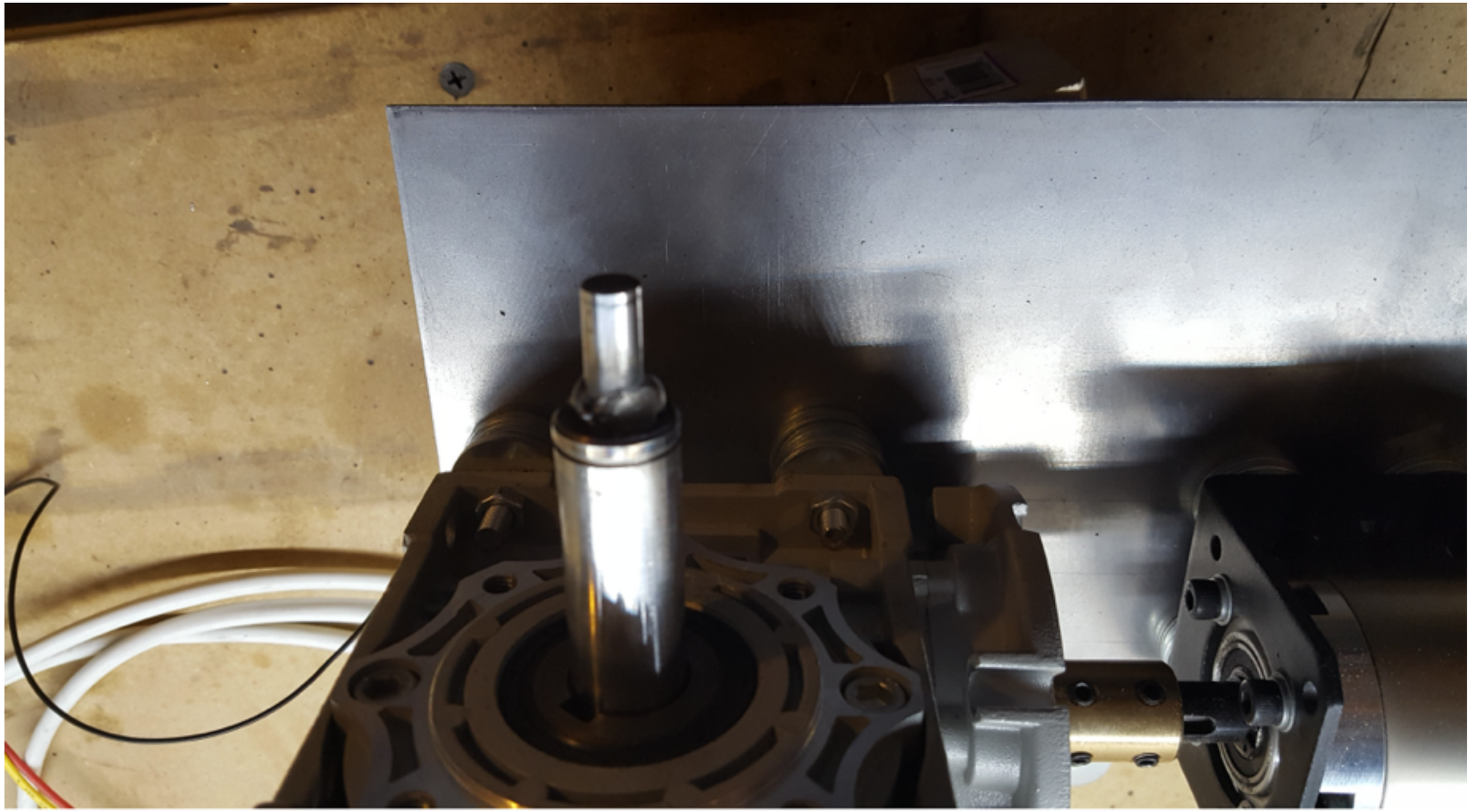
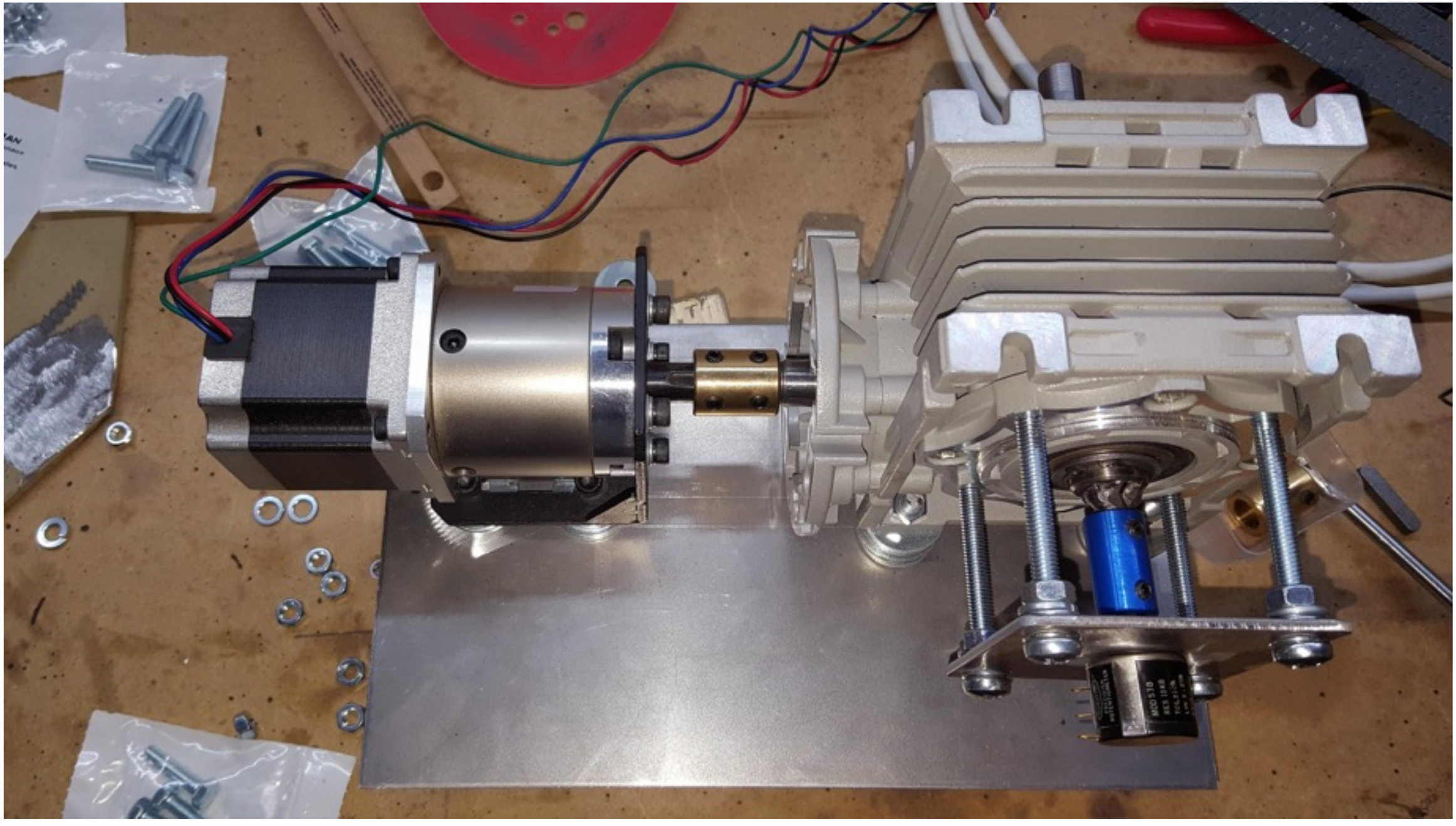
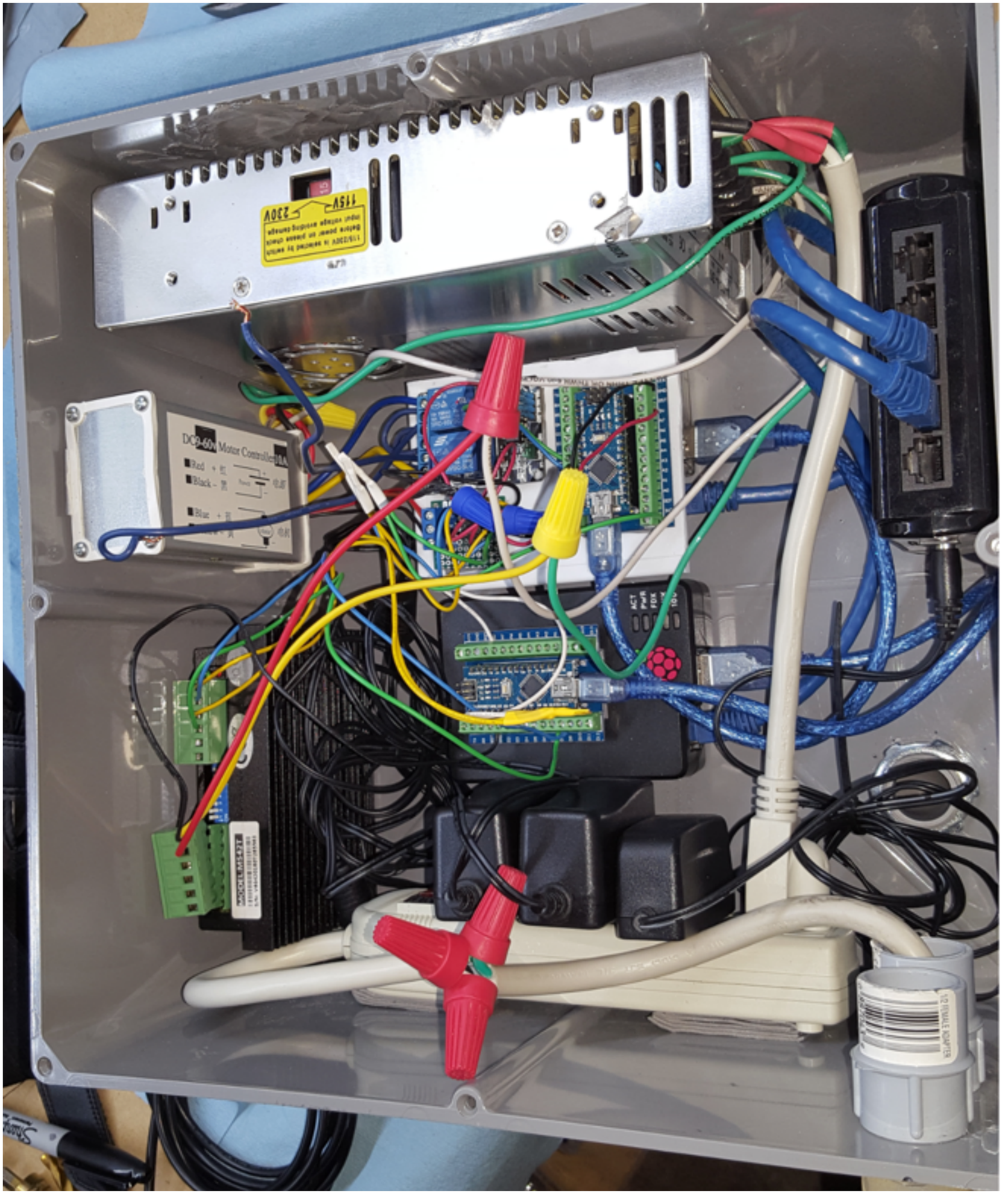
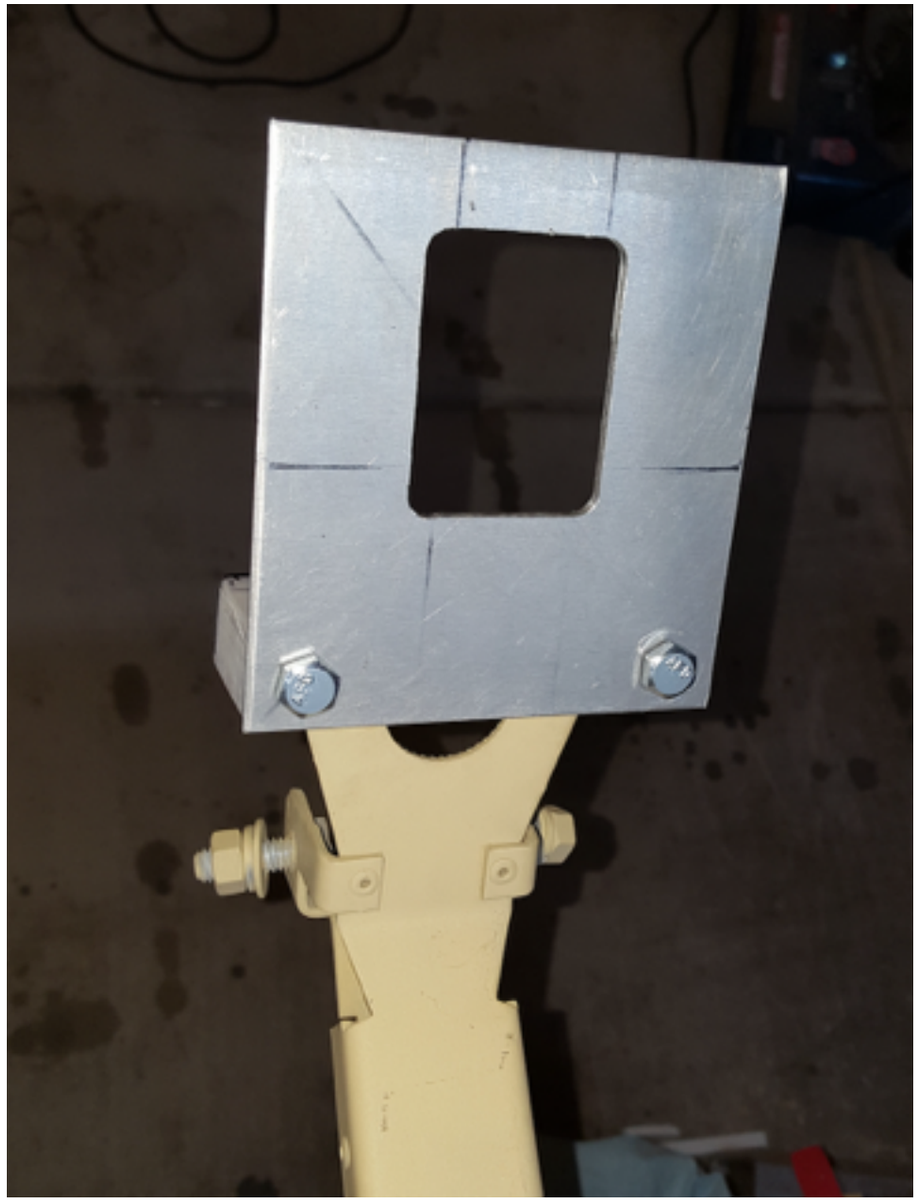


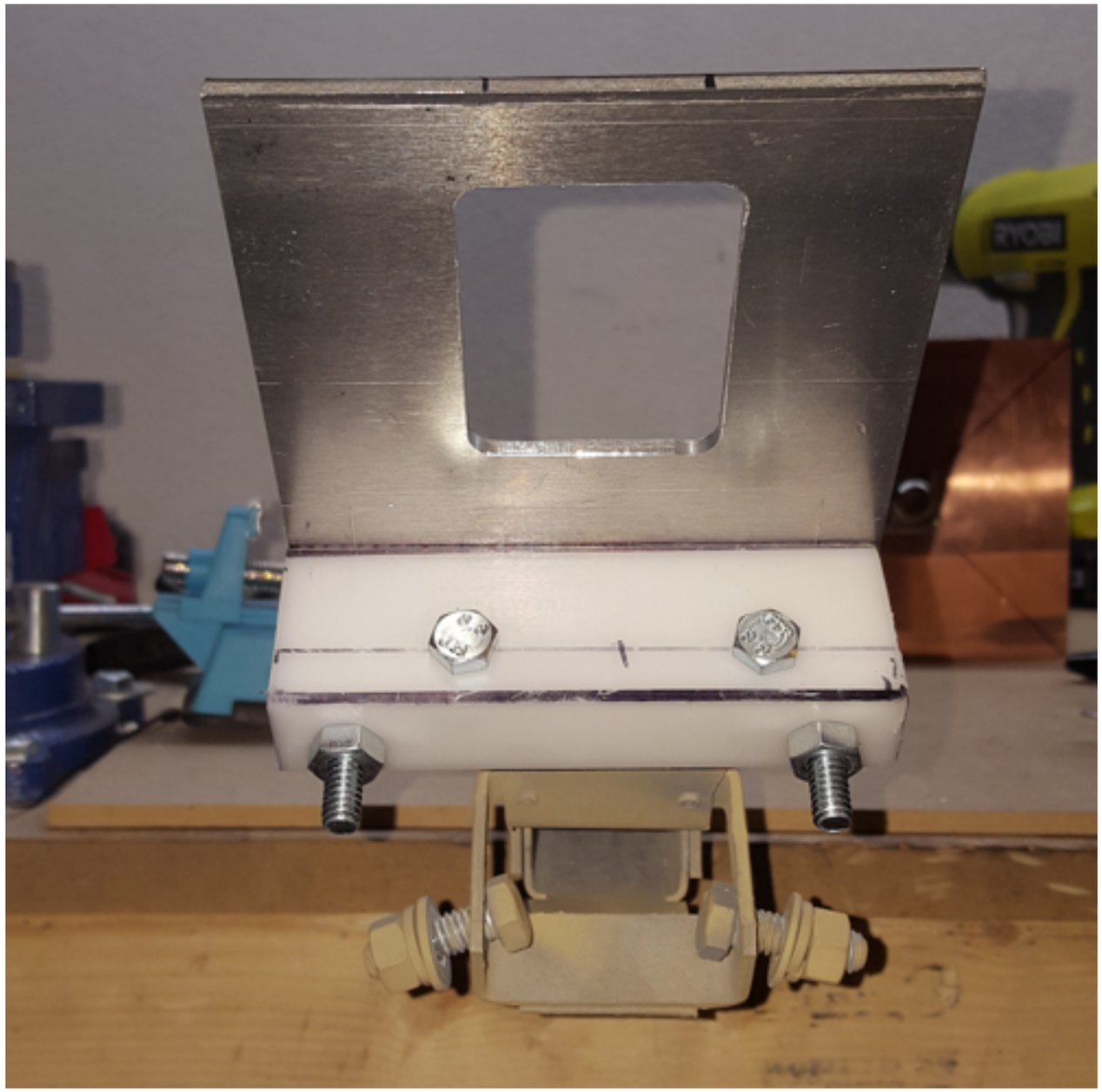





115V
230V
DC9-60V Motor Controller
Red +
Black -
Blue +


RYOBI

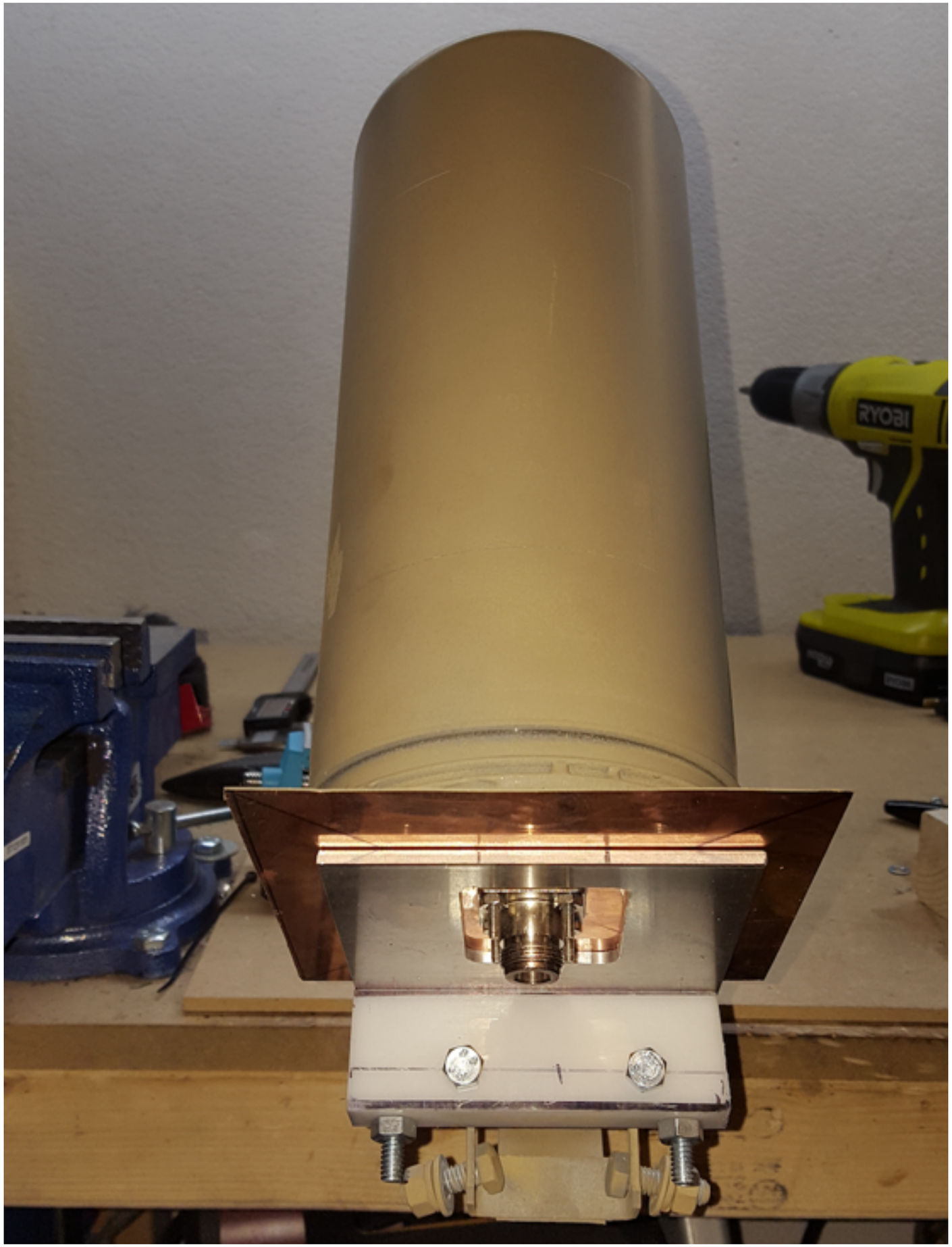



RYOBI

Helical Feed Notes

@uhf_satcom has great write up on inexpensive DIY helical feeds at:

http://uhf-satcom.com/sband/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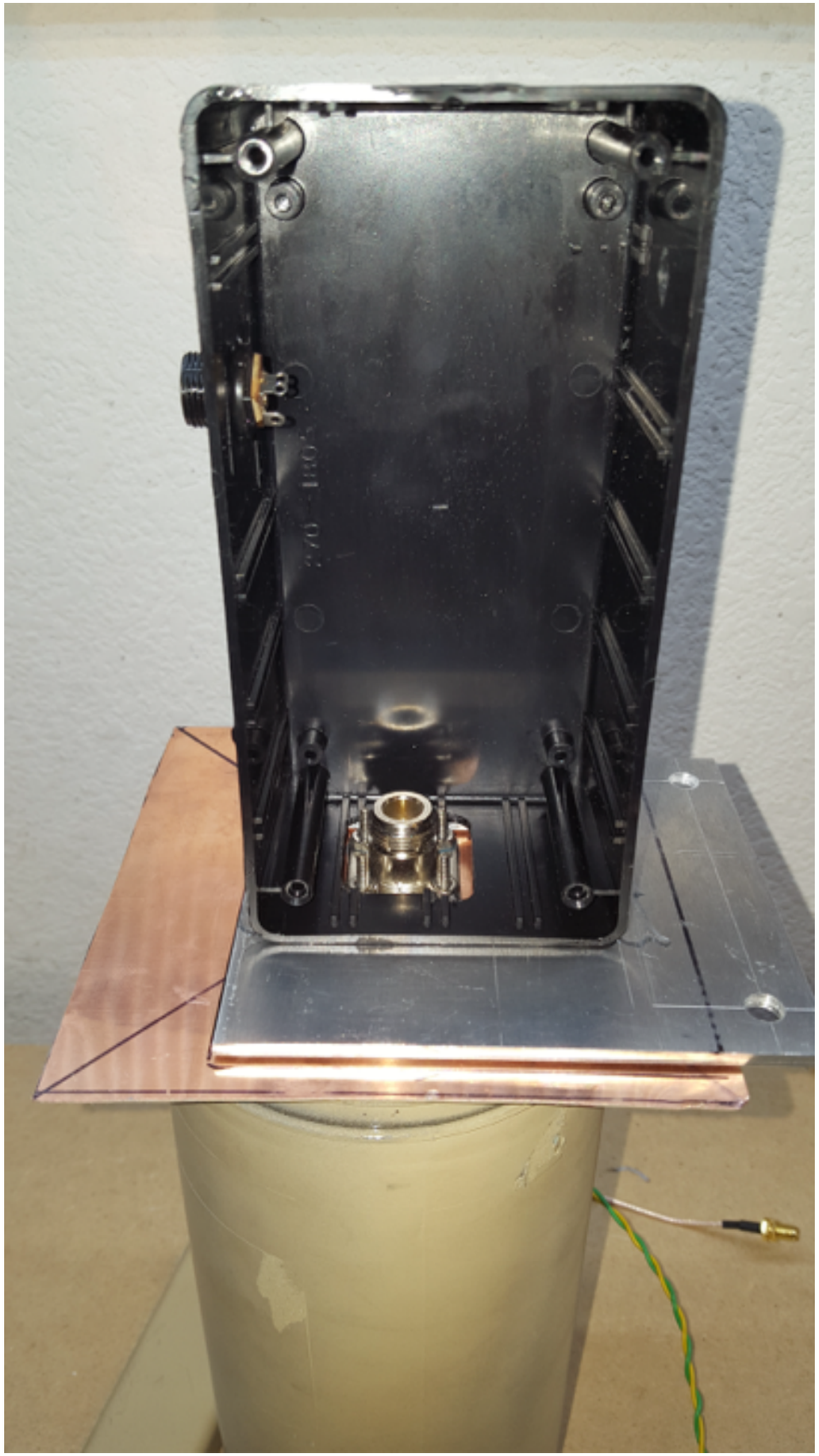
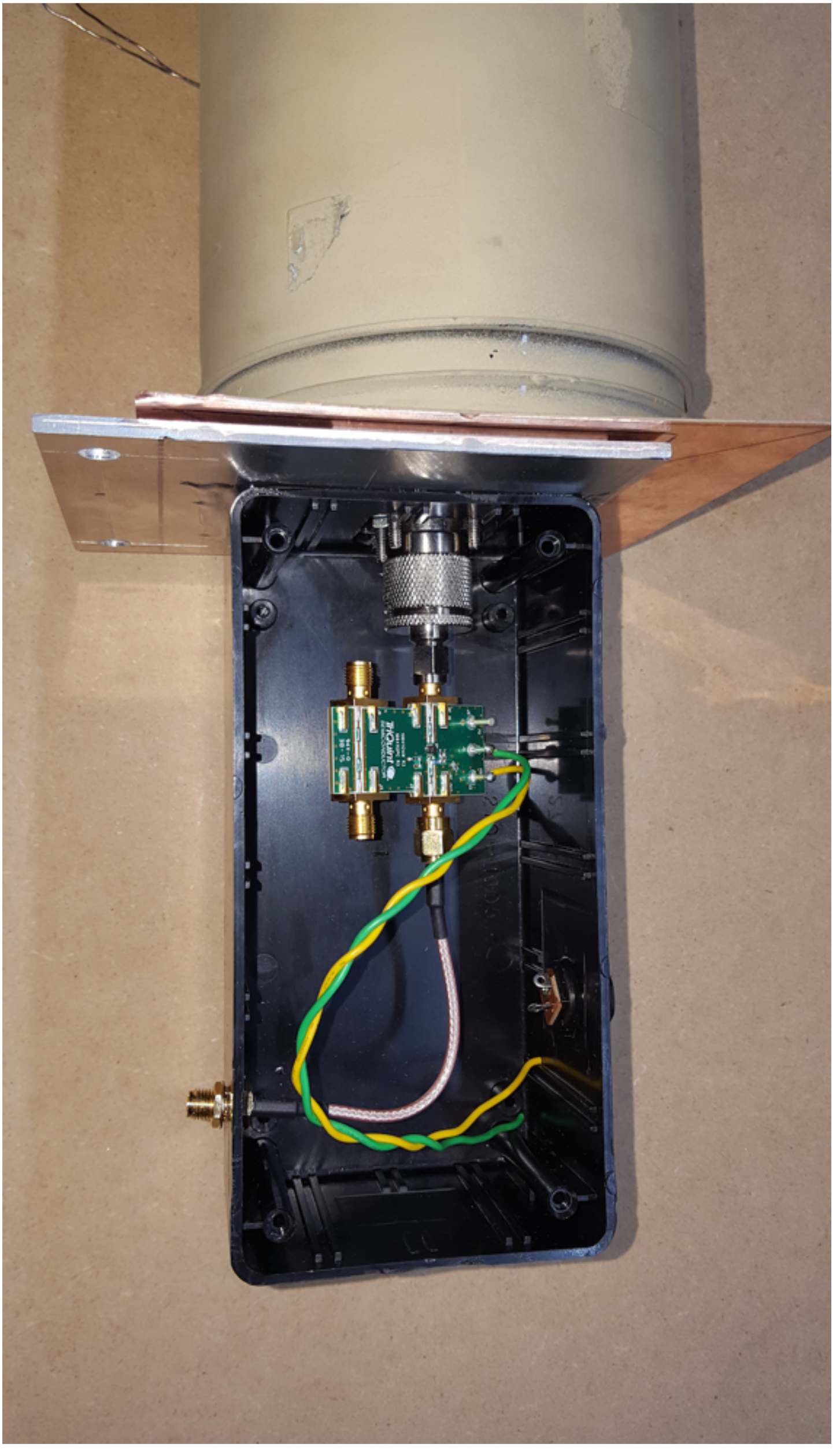
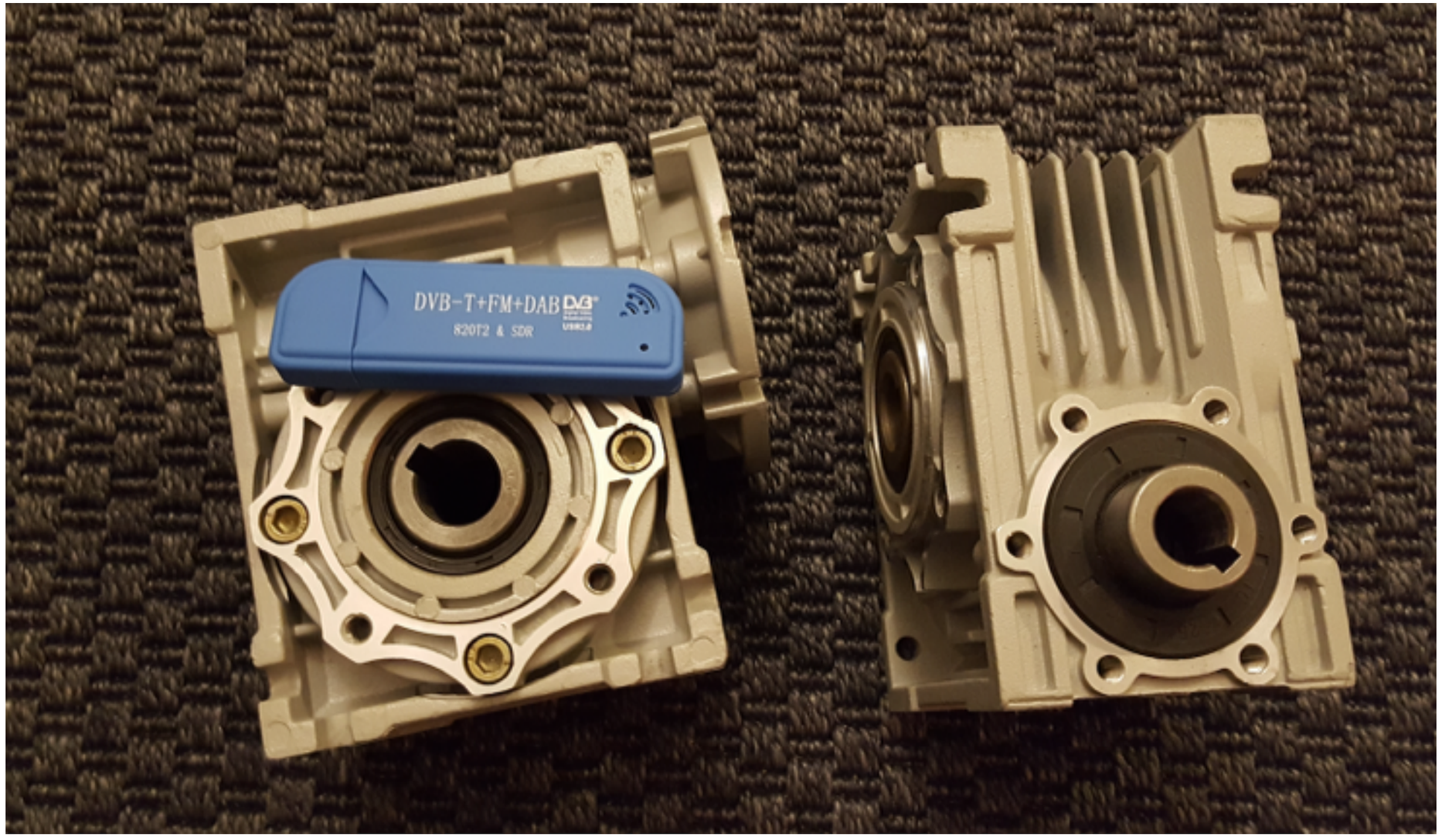


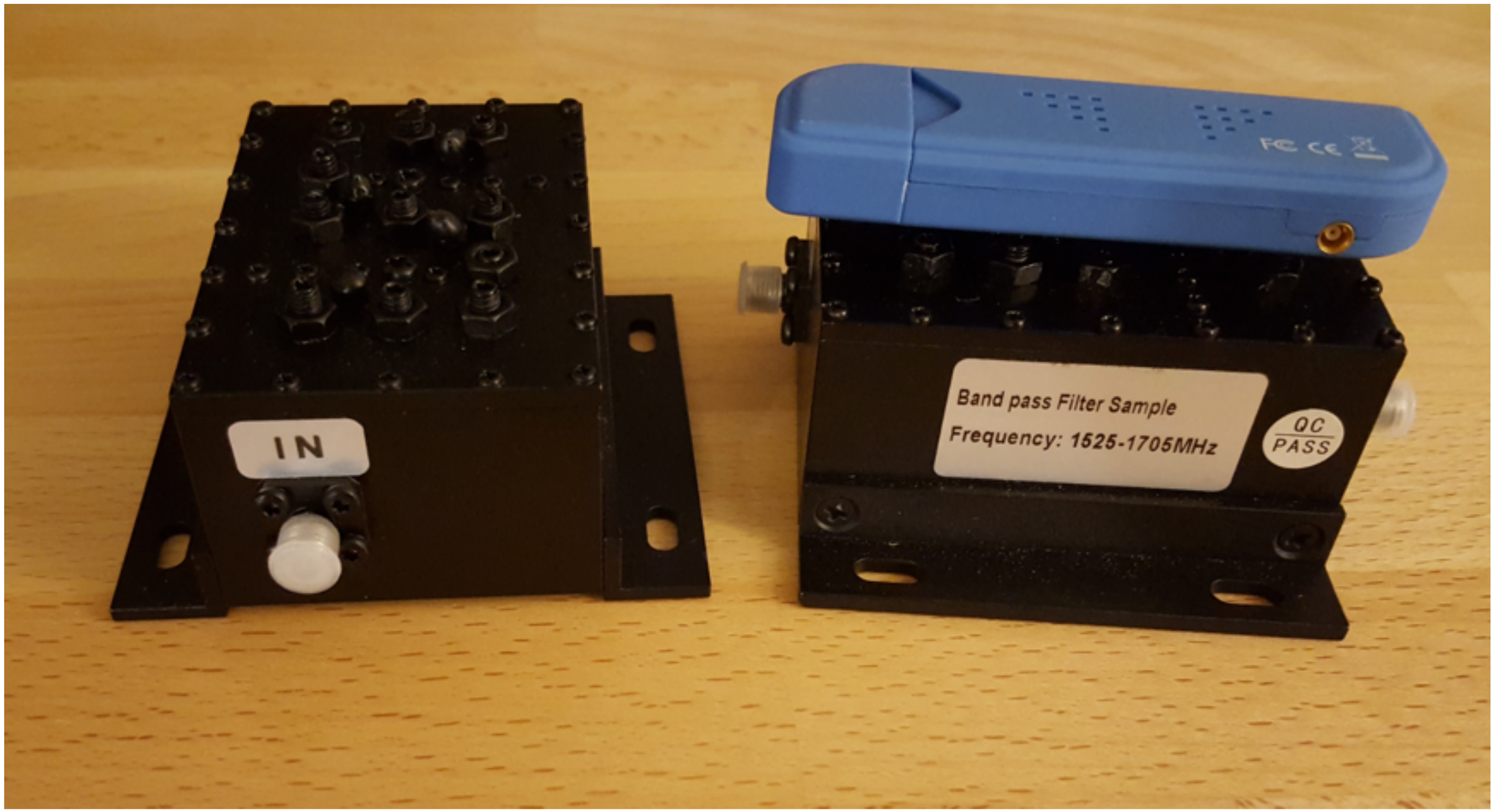


LNAs

- LNA4ALL
- TQP3M9037
- SPF5189

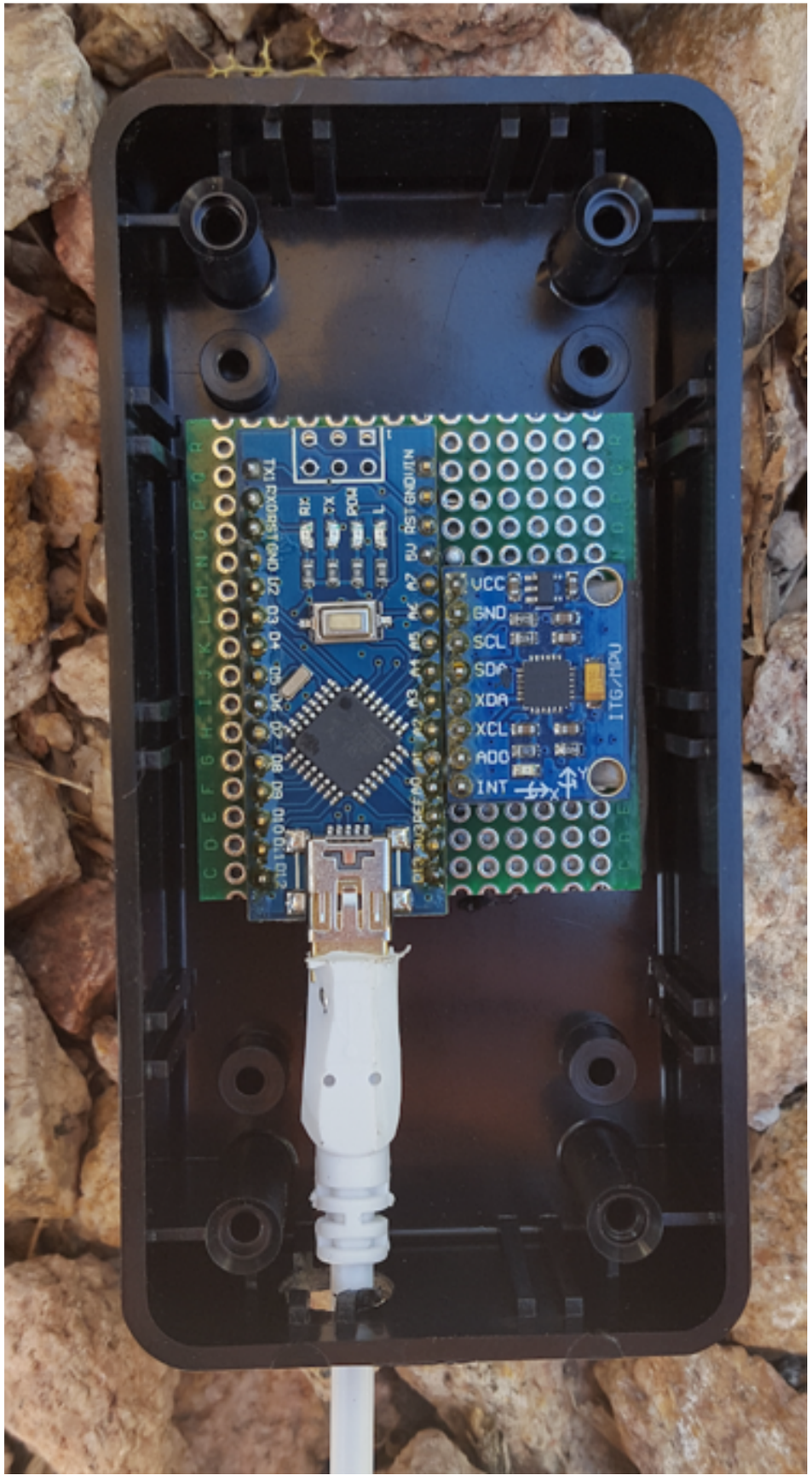


- Notes on wormgears



http://shop.sysmocom.de/products/filter-rf-l-band

- 6 DOF
- MPU-6050



- TP-Link 24dBi dish
- L-Com 1.9 GHz dish

Pelco Heavy-Duty Camera Mounts

- Can be found on Ebay
- Uses AC Motors

TLEs

A two-line element set (TLE) is a data format encoding a list of orbital elements of an Earth-orbiting object for a given point in time, the epoch.

NOAA 19 [+]
1 33591U 09005A   17207.16619454 .00000048 00000-0 51247-4 0 9993
2 33591 99.0955 174.5518 0014277 158.5571 201.6201 14.12197127435890

https://www.celestrak.com/ for current TLEs

https://en.wikipedia.org/wiki/Two-line_element_set

Software

- PyEphem
  - http://rhodesmill.org/pyephem/
  - Shout-out to sharebrained for blog post from 2011 on PyEphem.
  - http://www.sharebrained.com/2011/10/18/track-the-iss-pyephem/

```
home = ephem.Observer()
home.lat = '36.000'
home.lon = '-115.000'
home.elevation = 500

sat = ephem.readtle(tle[line1], tle[line2], tle[line3])
while True:
   home.date = datetime.datetime.utcnow()
   sat.compute(home)

   elevation = round(sat.alt * degrees_per_radian,2)
   az = round(sat.az * degrees_per_radian,2)
   time.sleep(1)
```

Software

- https://github.com/devnulling/satellite-tracker
  - Currently a place holder
  - Will push the code after a cleanup

- https://github.com/sudar/Arduino-Makefile
  - Allows remote firmware update to Arduinos when ran on connected RBPIs

- Uses a lot of ZMQ sockets for communication

- Will soon has a web interface and automatic scheduling

Software

- tracker.py
  - Takes in selected satellite's TLEs and produces Az/El outputs

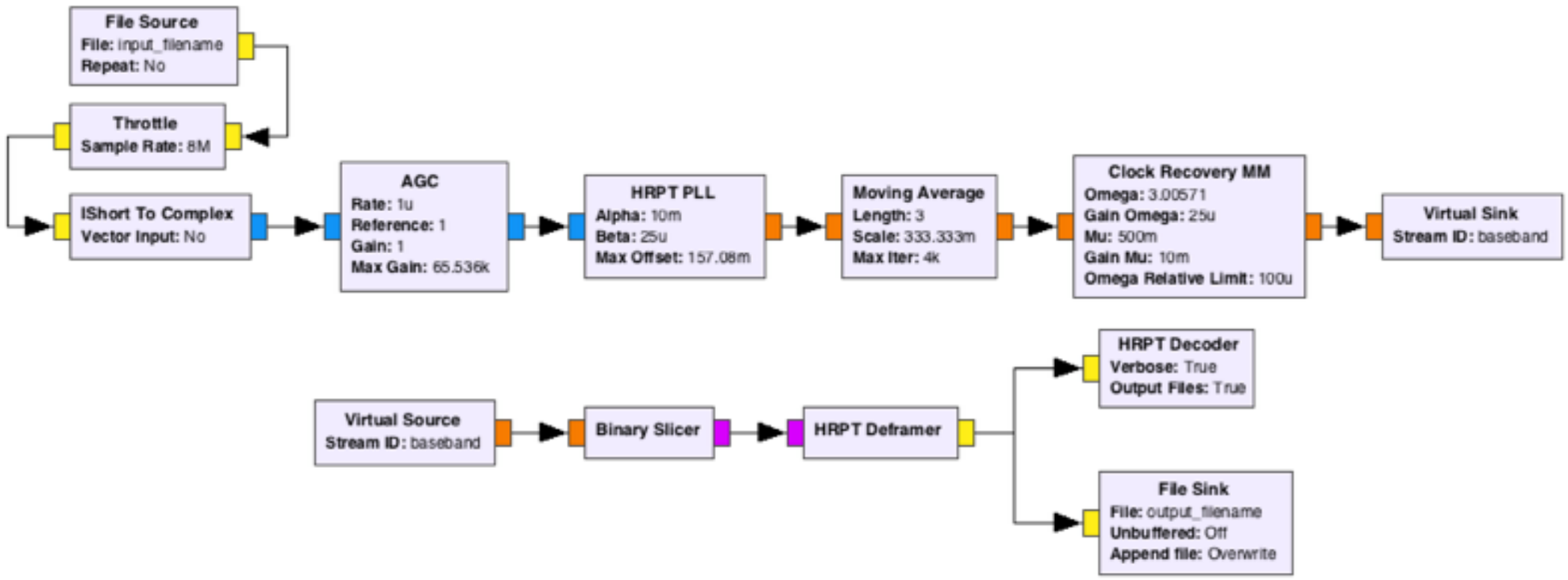
- az.py
  - Controls the Azimuth motor
  - Gets feedback from precision potentiometer for position
- az.ino
  - Azimuth controller (arduino) firmware

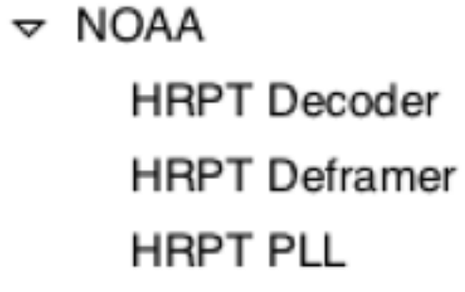
- el.py
  - Controls Elevation motor
  - Gets feed back from MPU-6050 for current angle
- el.ino
  - Elevation controller (arduino) firmware
- mpu.ino
  - MPU-6050 firmware

- local_control.py
  - For debugging / manual control

- tle_dl.py
  - Downloads TLEs from Celestrak

GNU Radio / gr-noaa

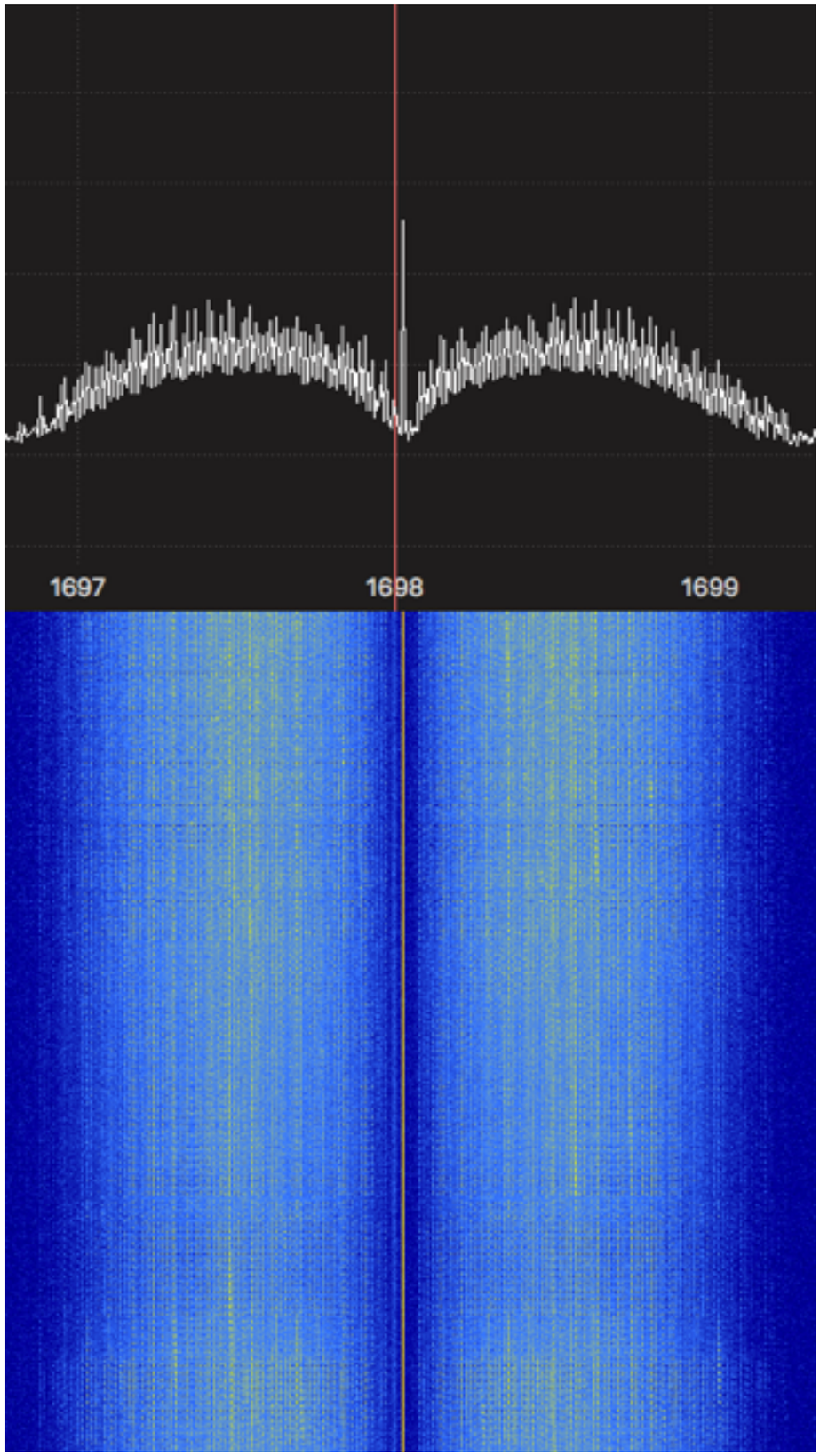


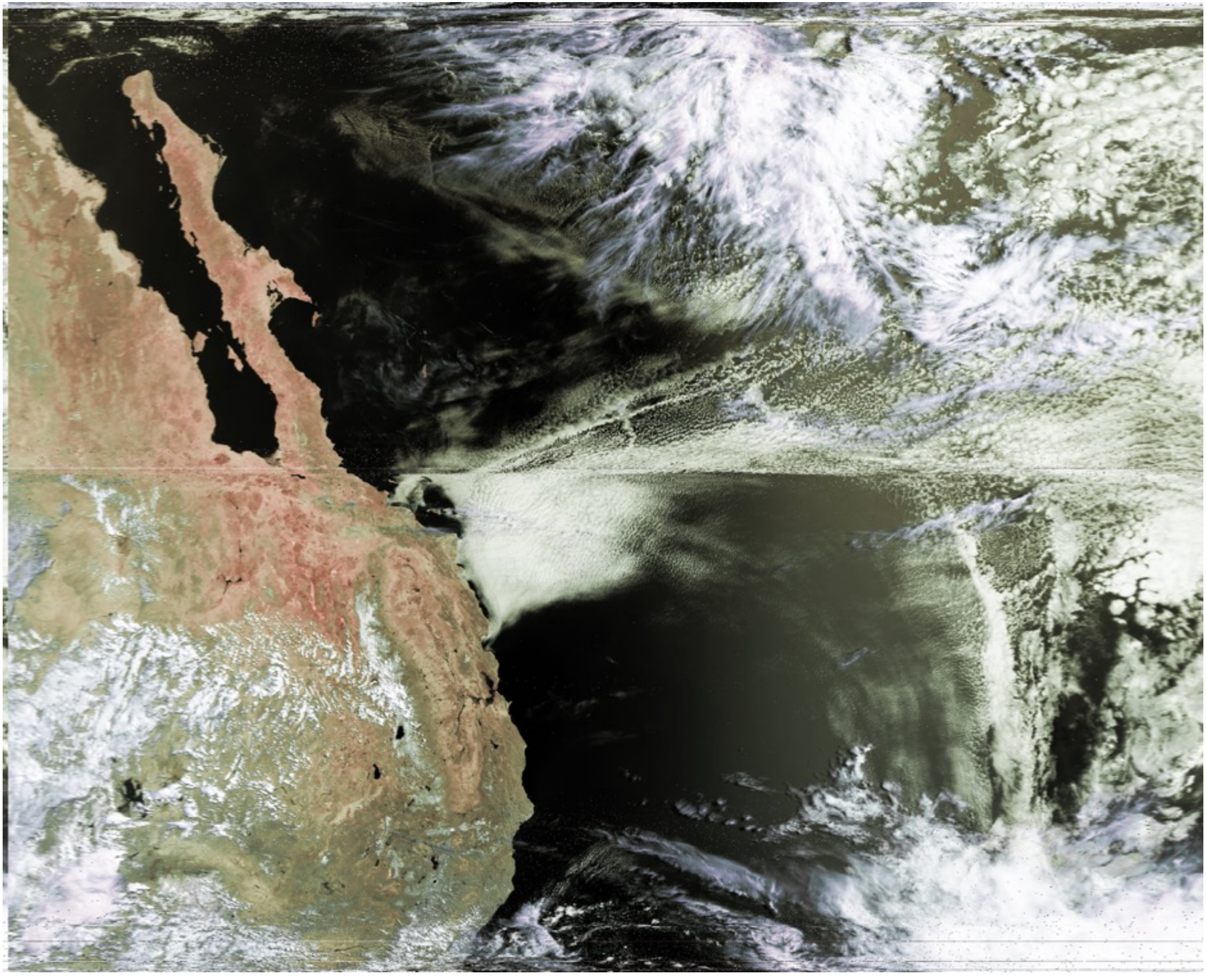


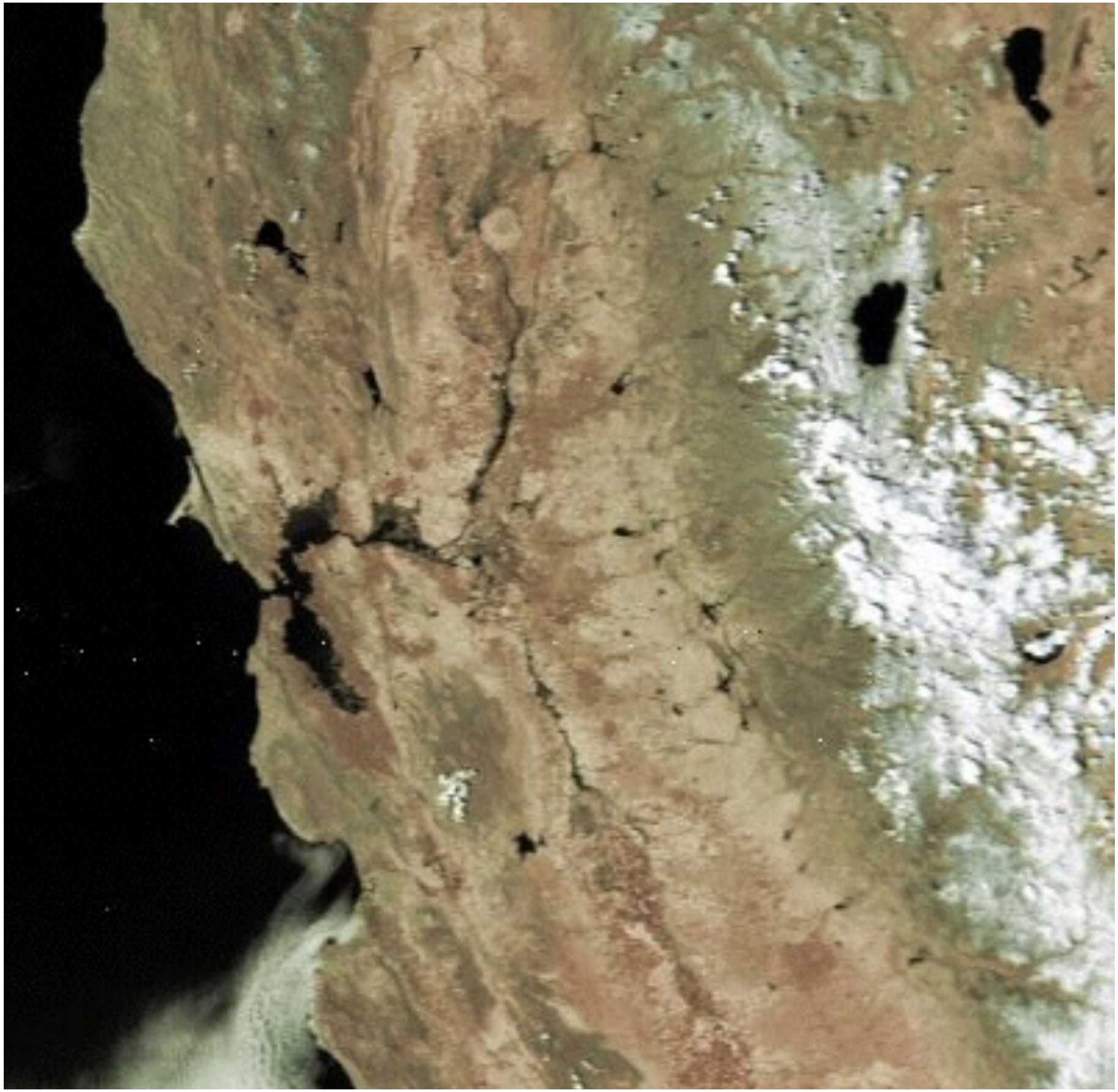
HRPT Reader

- Created by David Taylor
- http://www.satsignal.eu/software/hrpt.htm
- File from HRPT / File Sink needs extension .raw16

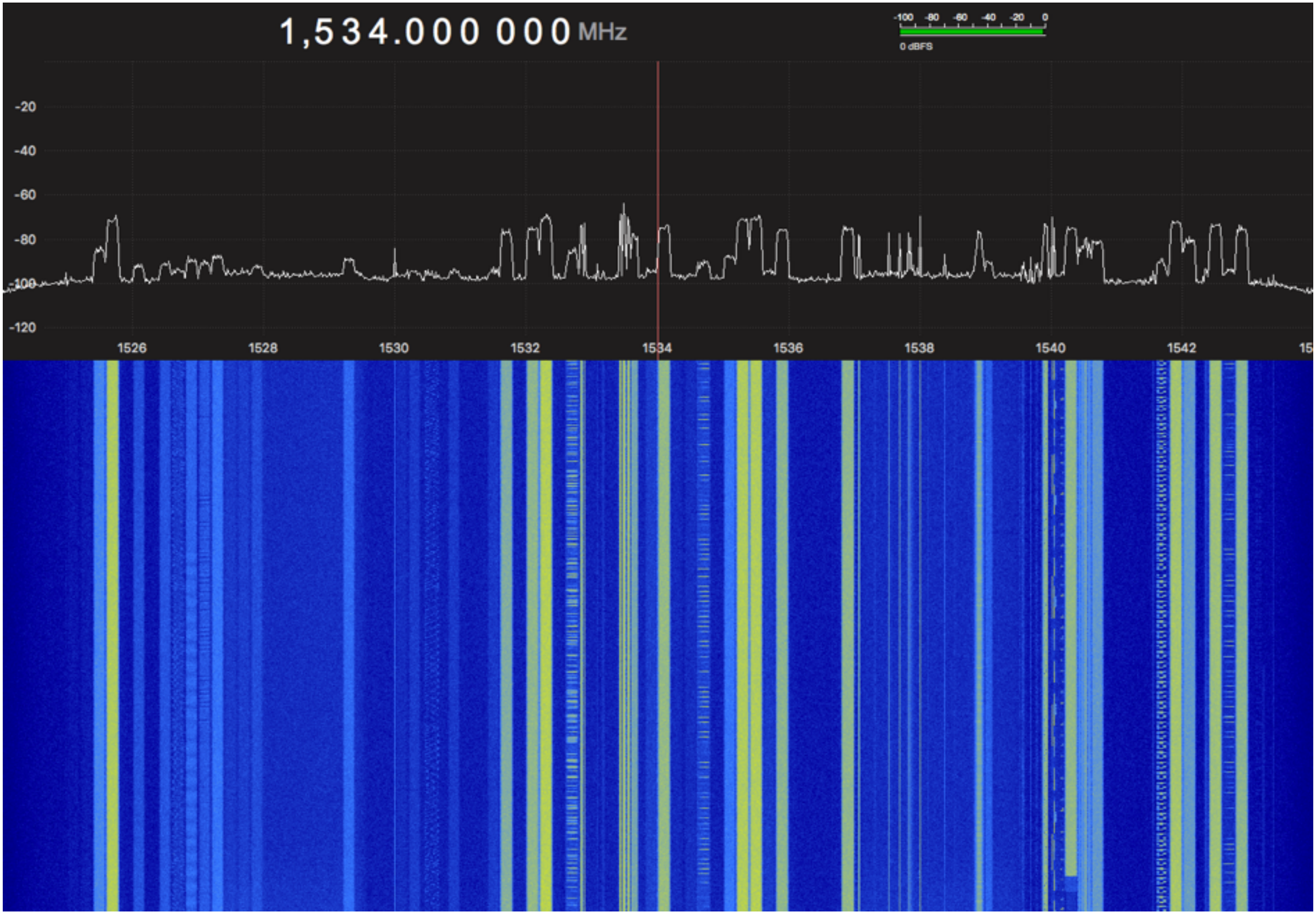
NOAA-19 HRPT



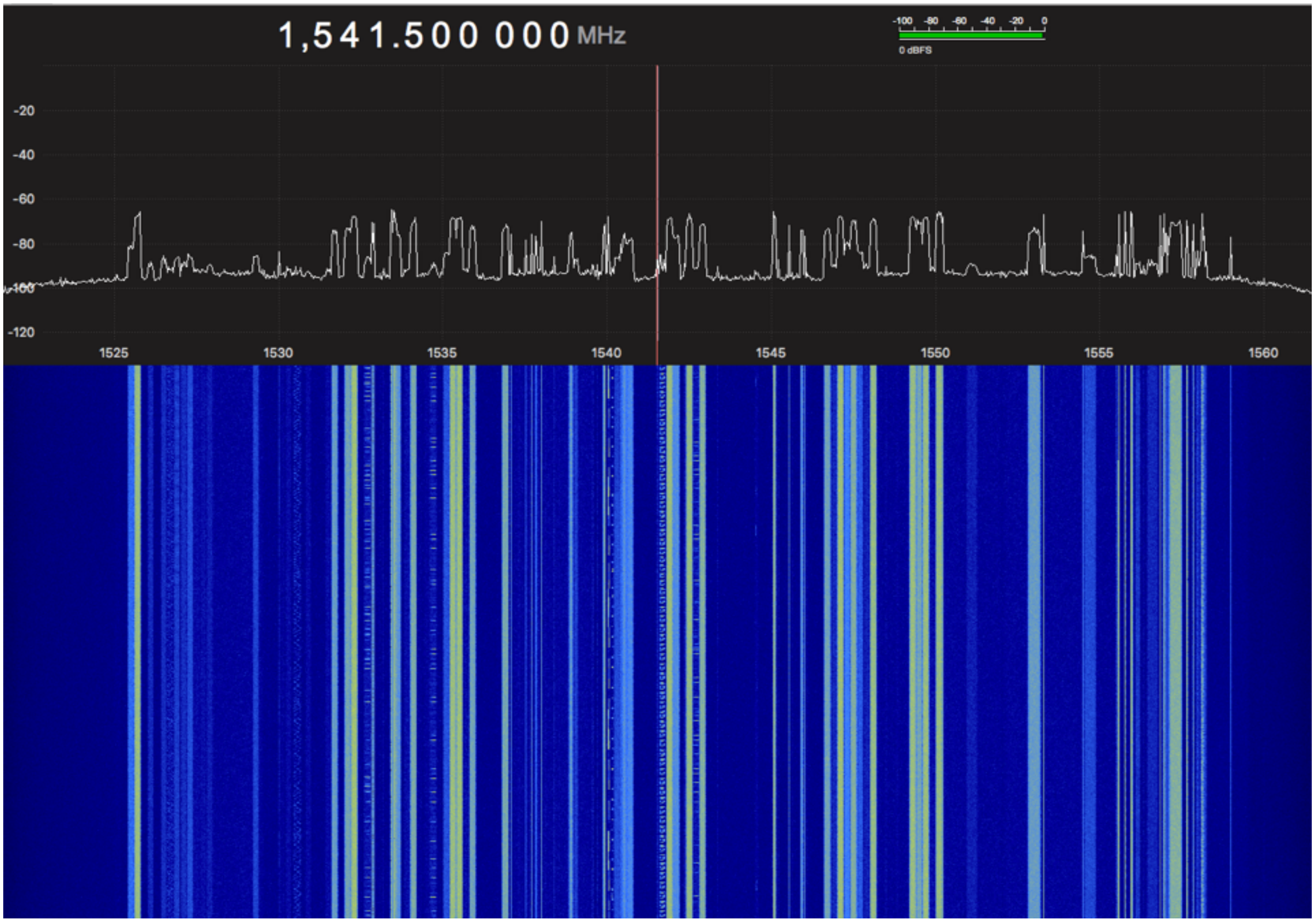




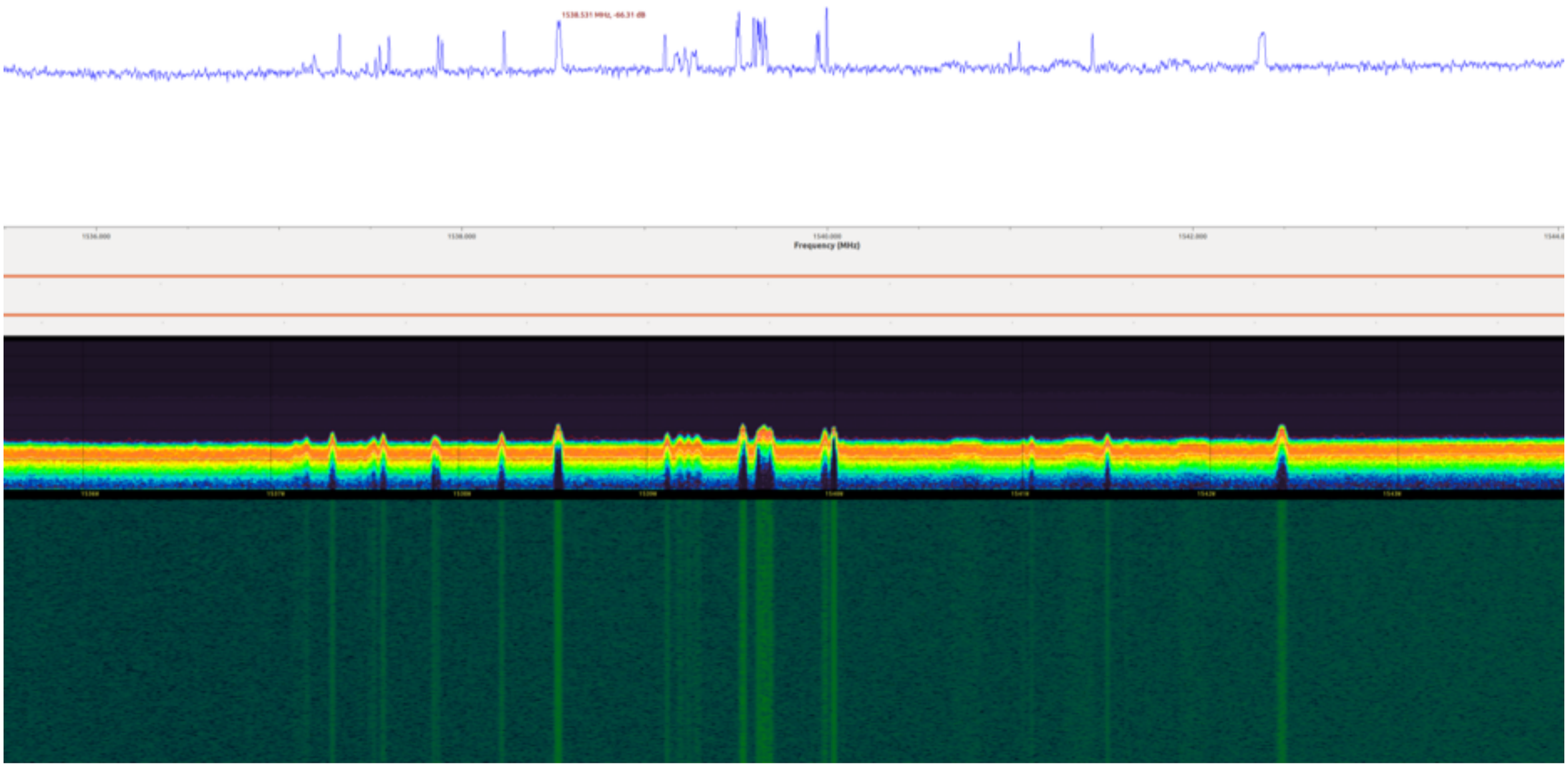
Inmarsat 98W (CONUS)



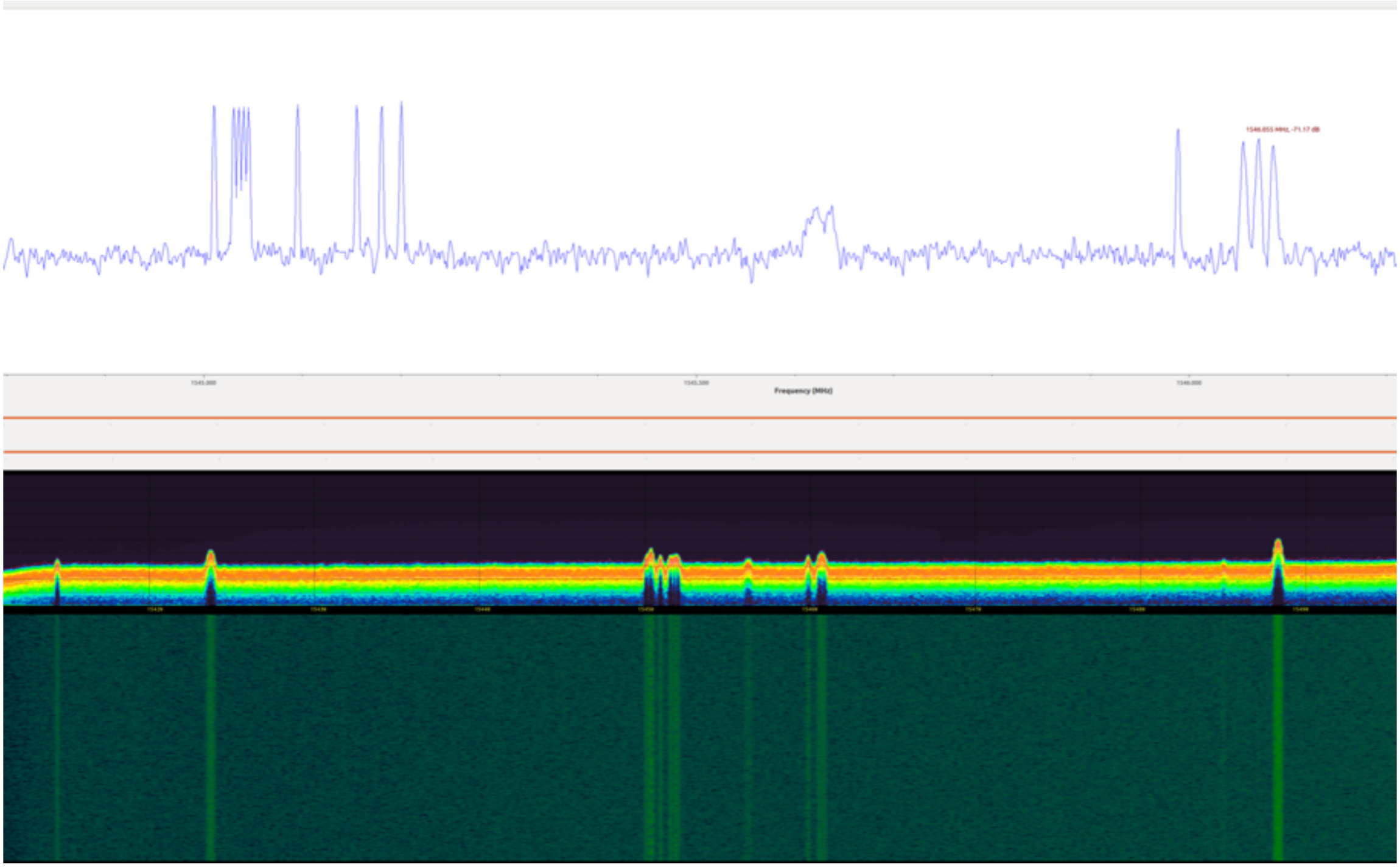
Inmarsat 98W (CONUS)



Inmarsat POR

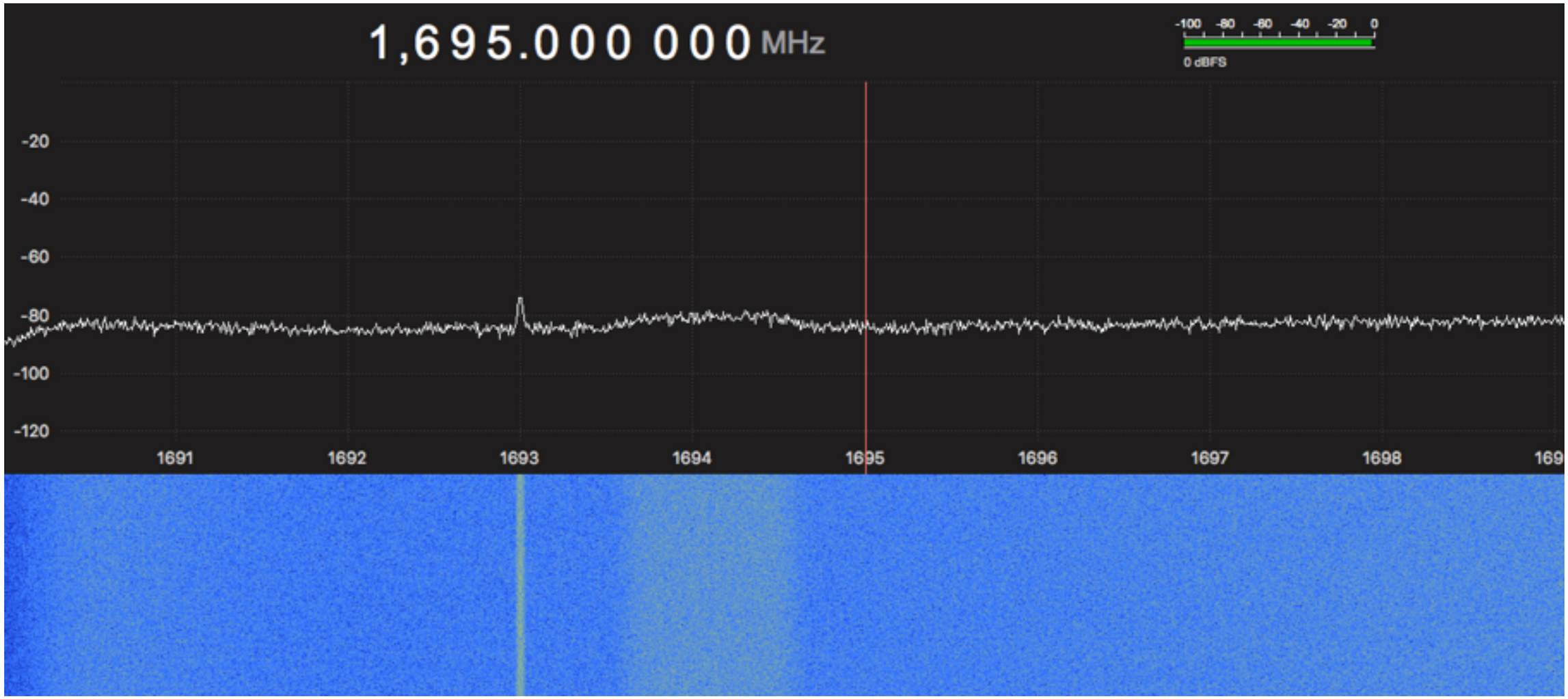


Inmarsat POR

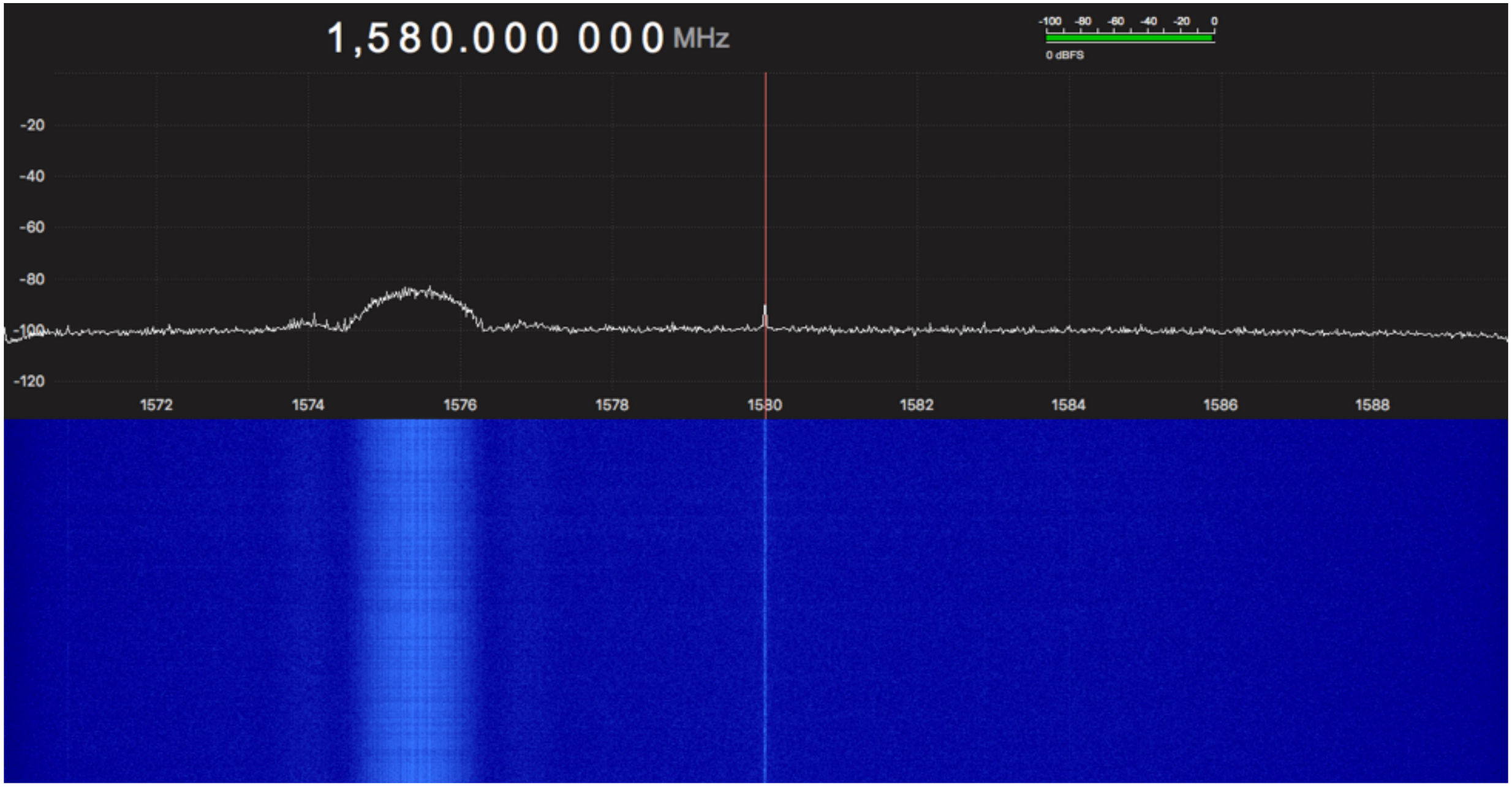


GOES-13

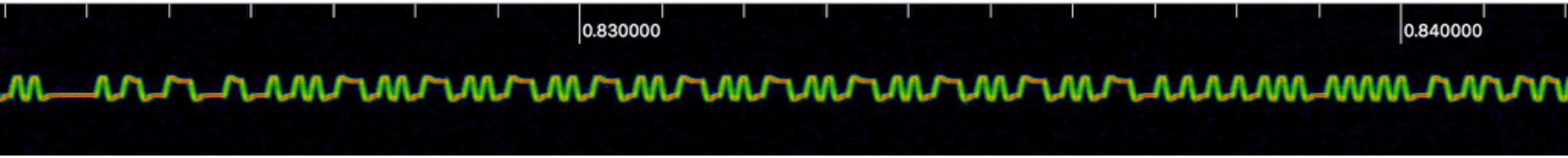
Blocked by trees

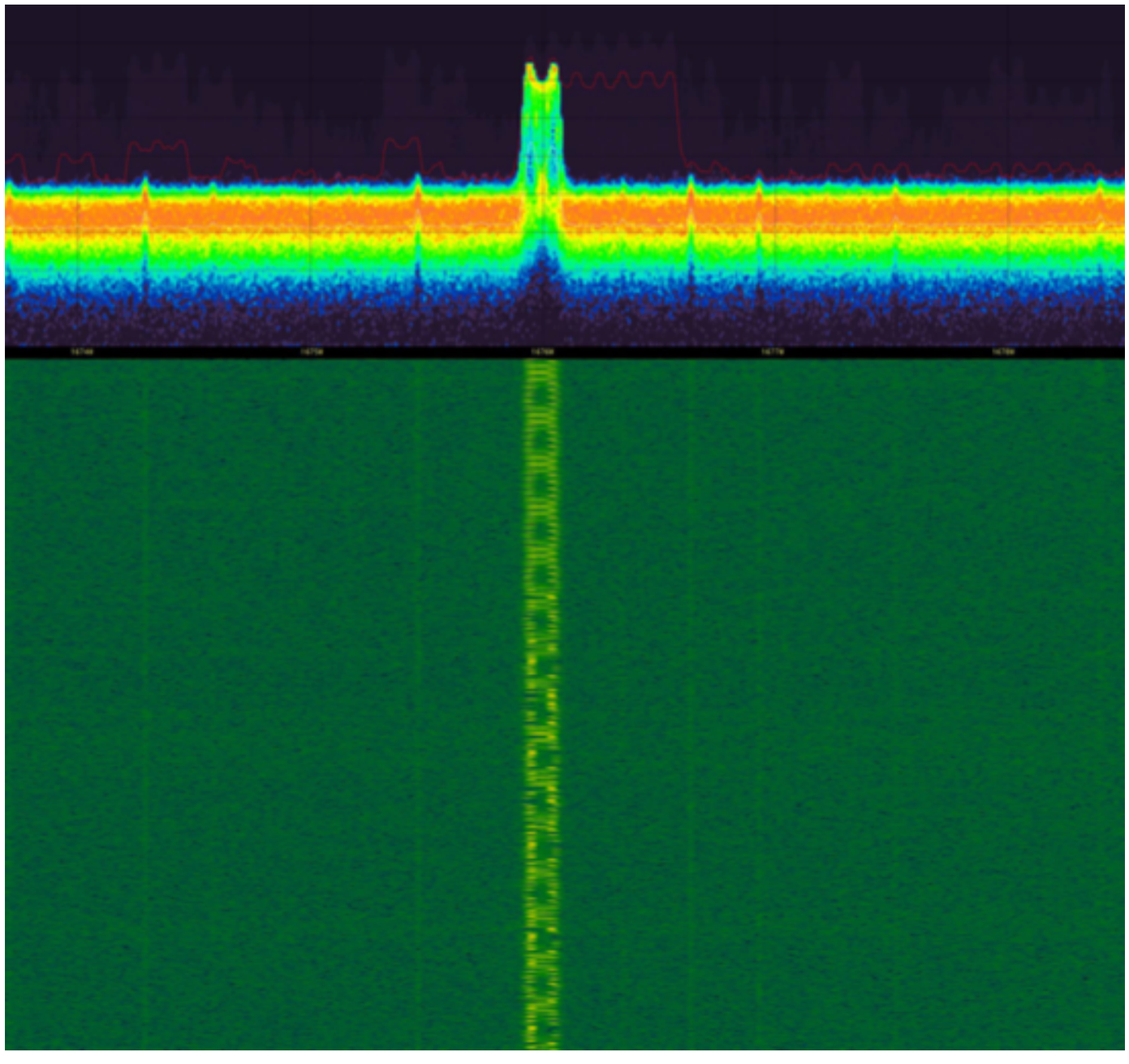


GPS


1,580.000 000 MHz
-100 -80 -60 -40 -20 0
0 dBFS
-20
-40
-60
-80
-100
-120
1572
1574
1576
1578
1580
1582
1584
1586
1588

Radiosonde





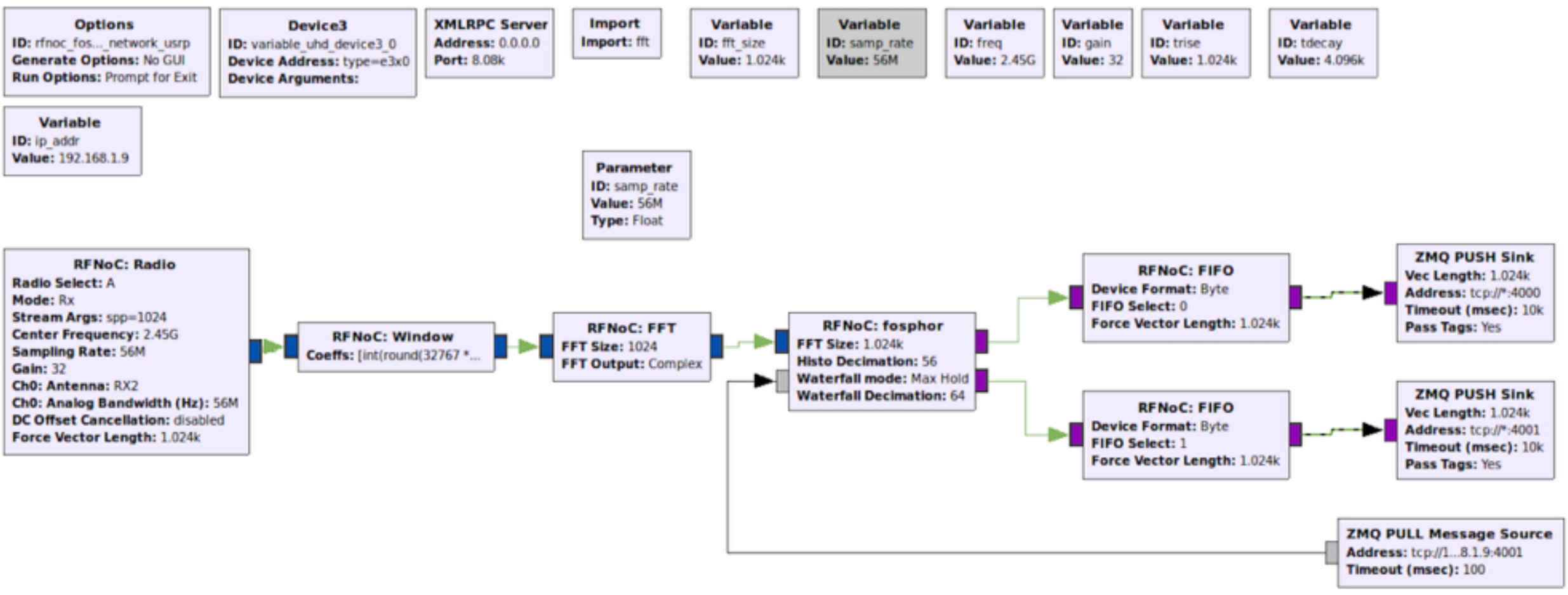
Live Demo

- USRP E310
- 2x2 MIMO Embedded USRP
- Zynq 7020 FPGA / 2 core ARM
- Running RFNoC gr-fosphor

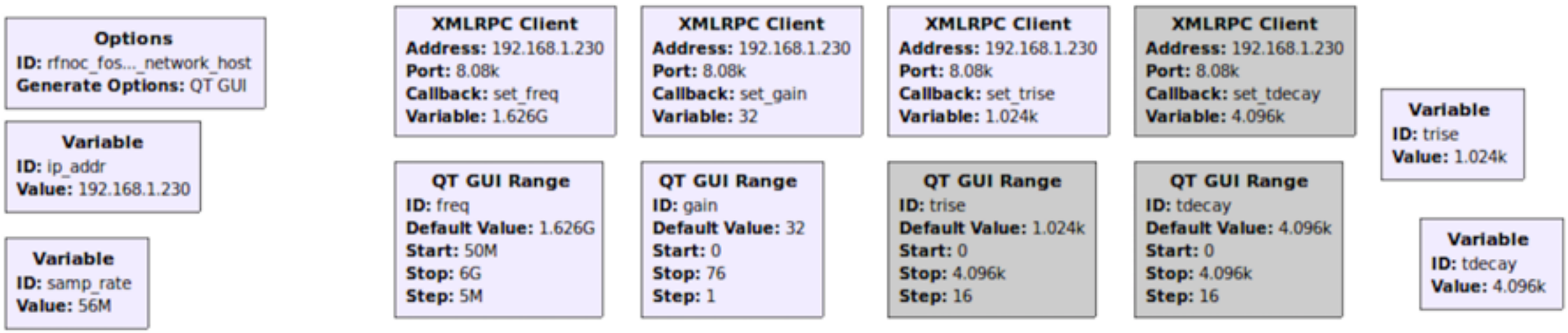
RFNoC Fosphor

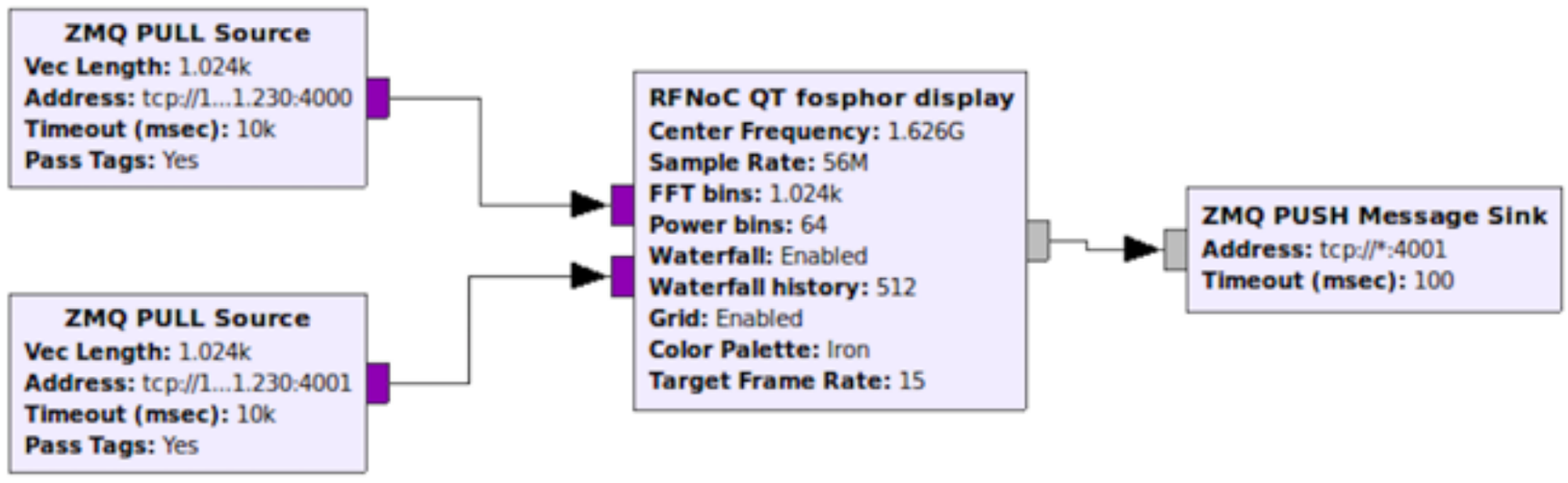
- Created by Sylvain Munaut @tnt
- Example flowgraphs located in
  - https://github.com/ettusresearch/gr-ettus
- Offloads the heavy DSP for FFT to FPGA

RFNoC Fosphor



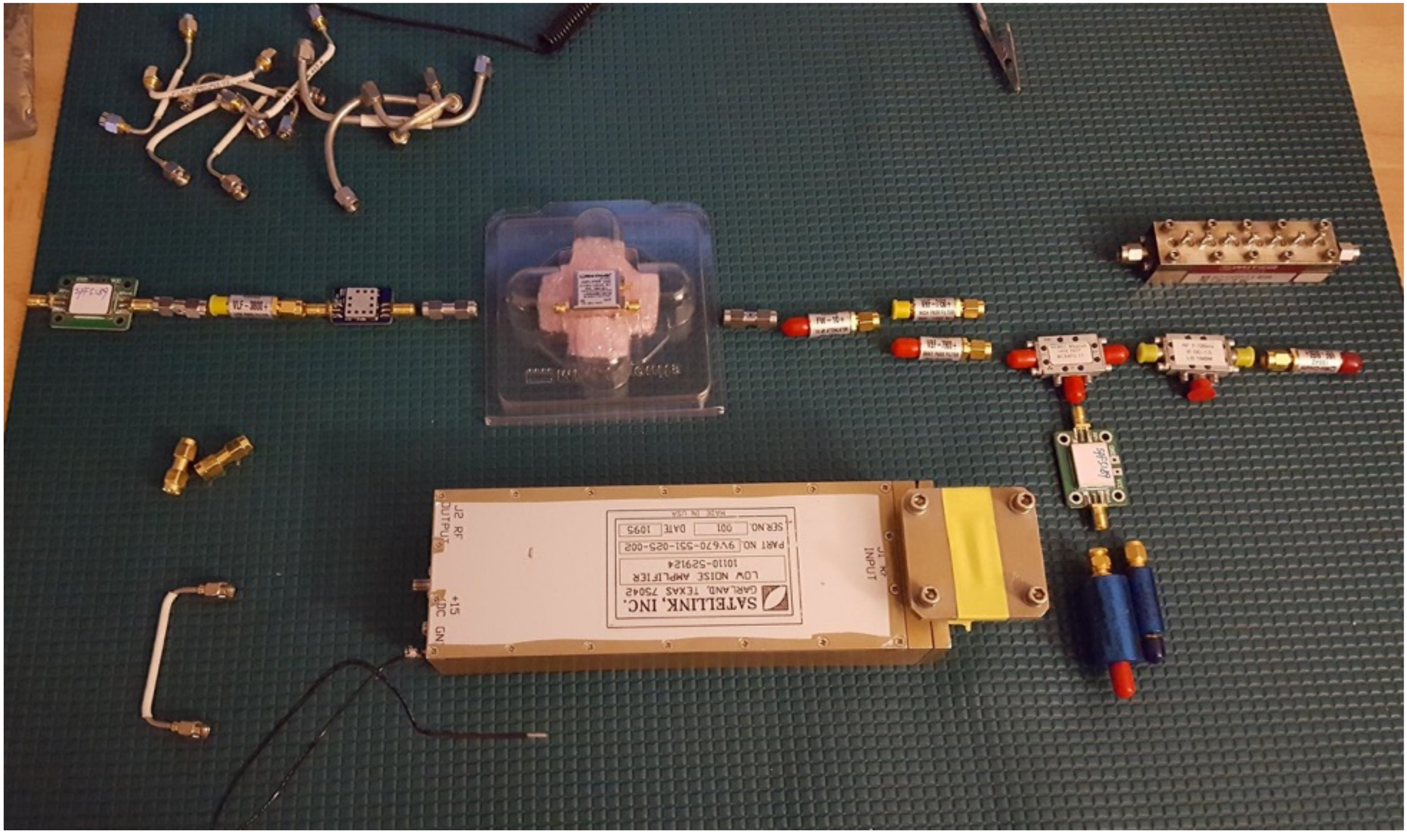
RFNoC Fosphor





Live Demo

Coming up soon... (stay tuned)



Special Thanks

- All the ##rtlsdr and #hearsat folks
- patchvonbraun
- @usa_satcom
- @uhf_satcom
- @lucasteske
- Cyberspectrum
- SynShop