

SatNOGS

Crowd-sourced satellite operations

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Libre Space Foundation



Libre Space Foundation





HACKADAY

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December 23, 2017

SATNOGS WINS THE 2014 HACKADAY PRIZE

by: [Mike Szczys](#)

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November 13, 2014



SEARCH

SEARCH

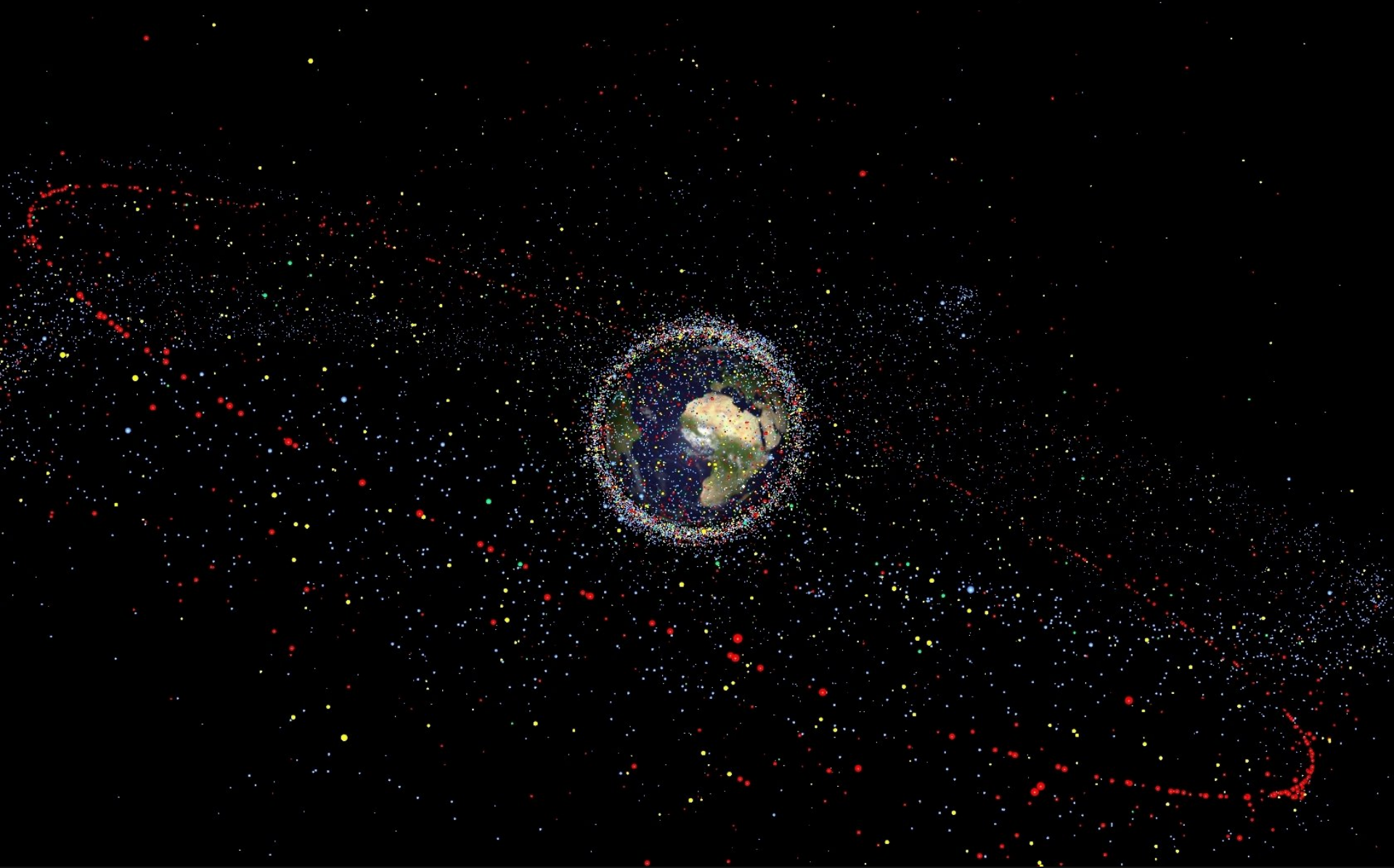
NEVER MISS A HACK



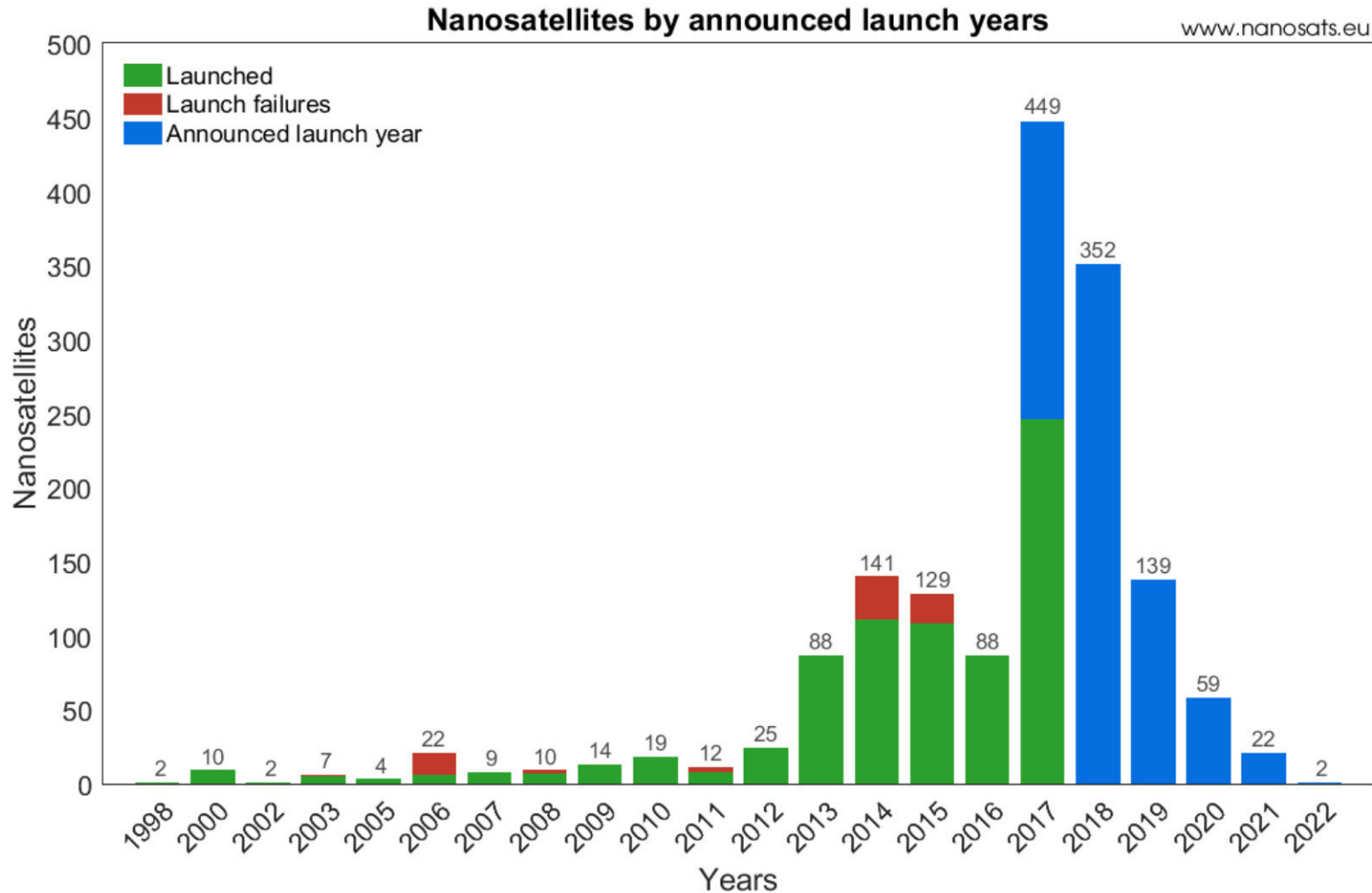
SUBSCRIBE

SUBSCRIBE

Hunting Satellites



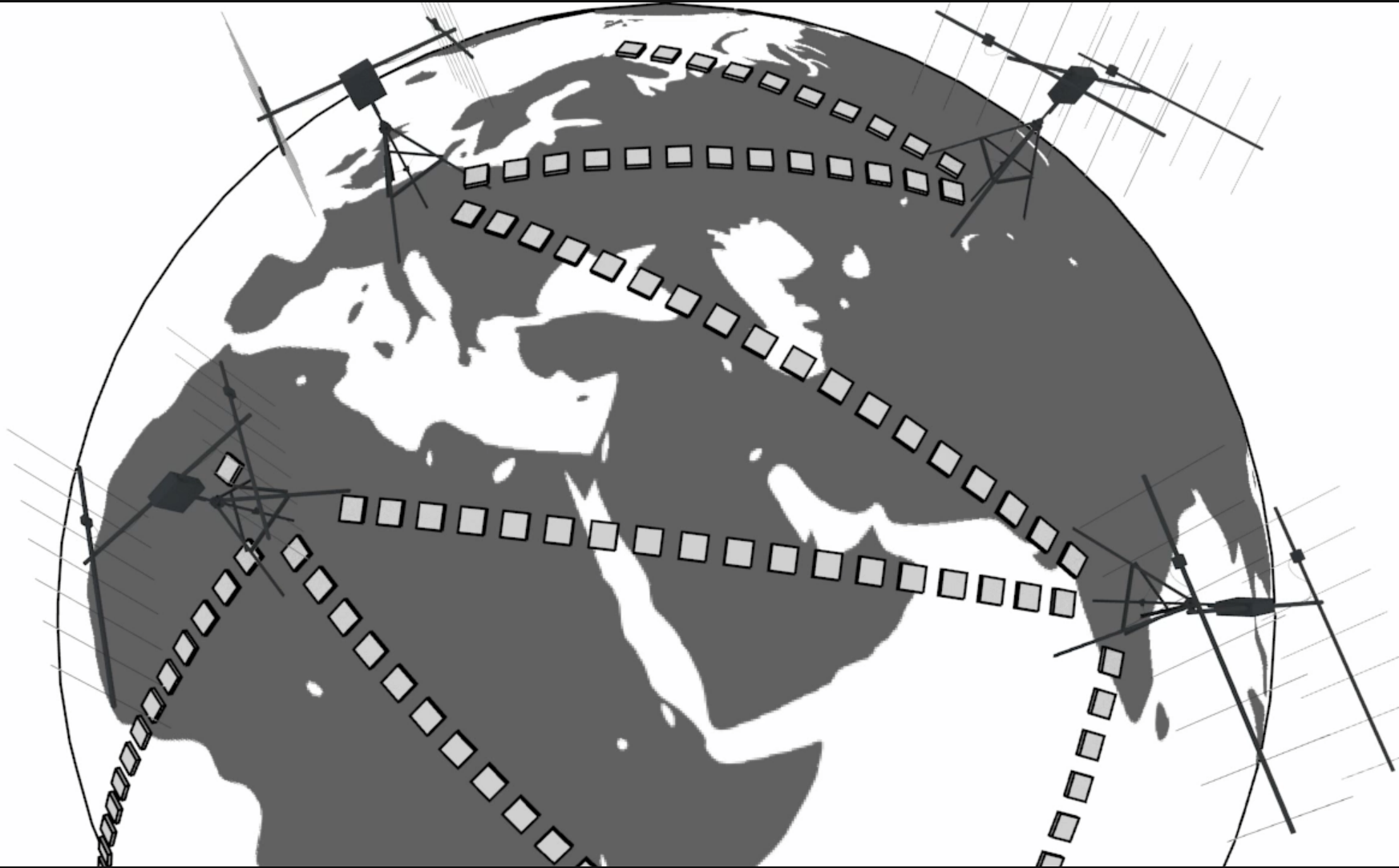
Scale?



Scale?



Build a Network

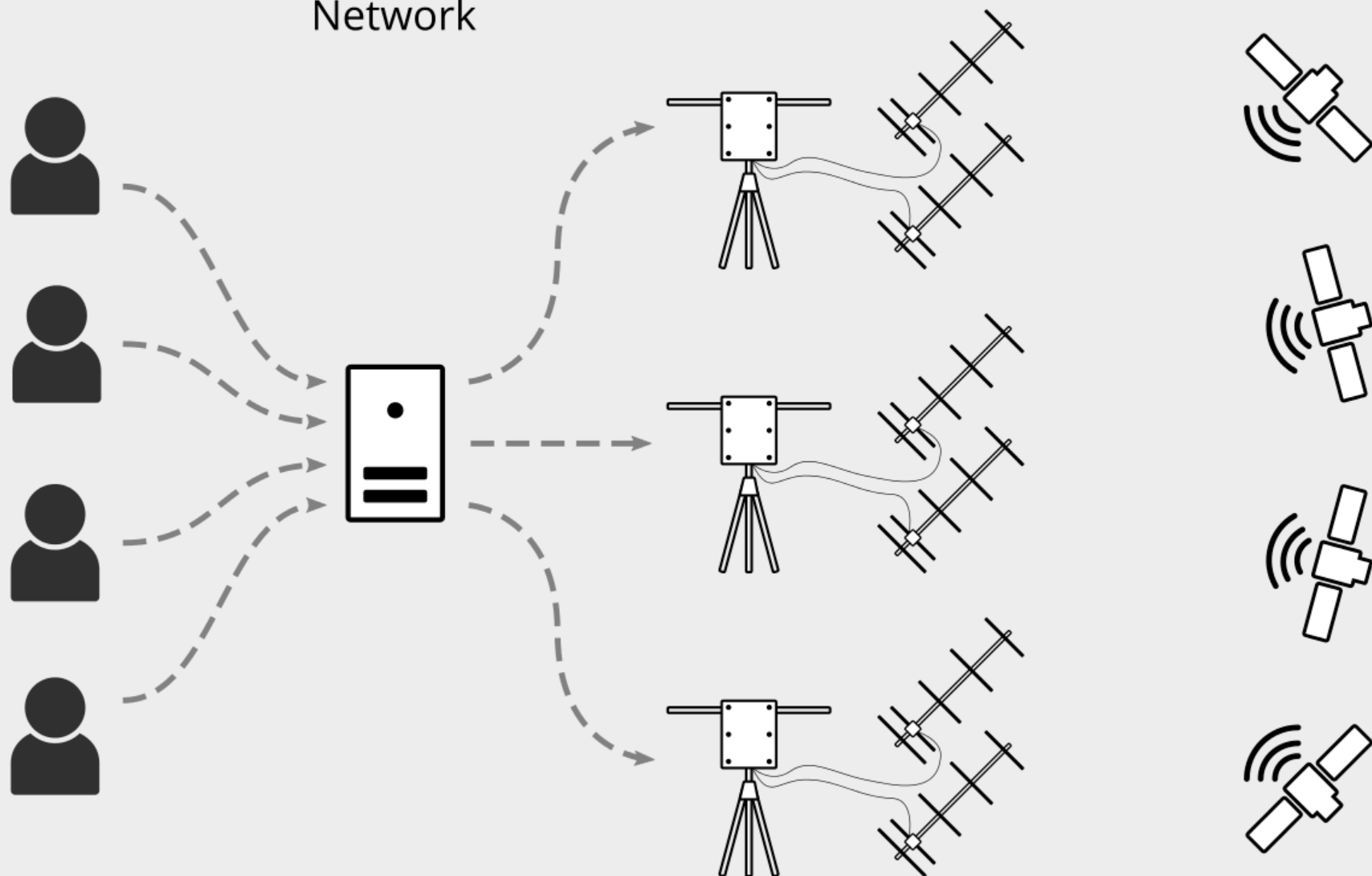


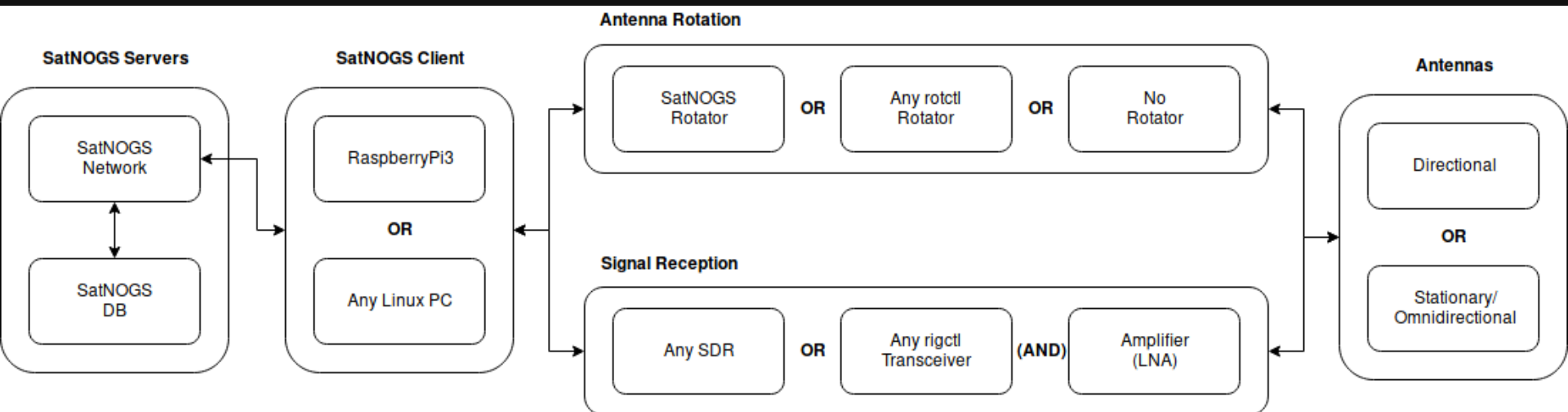
Users

Global
Management
Network

Ground Stations

Satellites





SatNOGS

Network

Client

Rotator

Antennas

DB

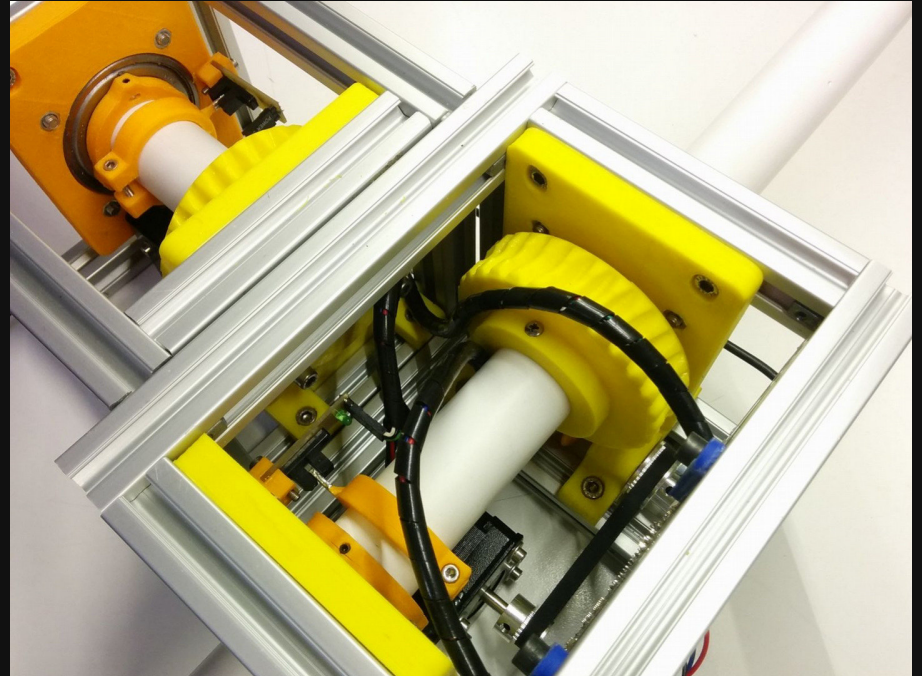
Rotator

Bring your own

- Any rotator supported by hamlib/rotctld

Build your own

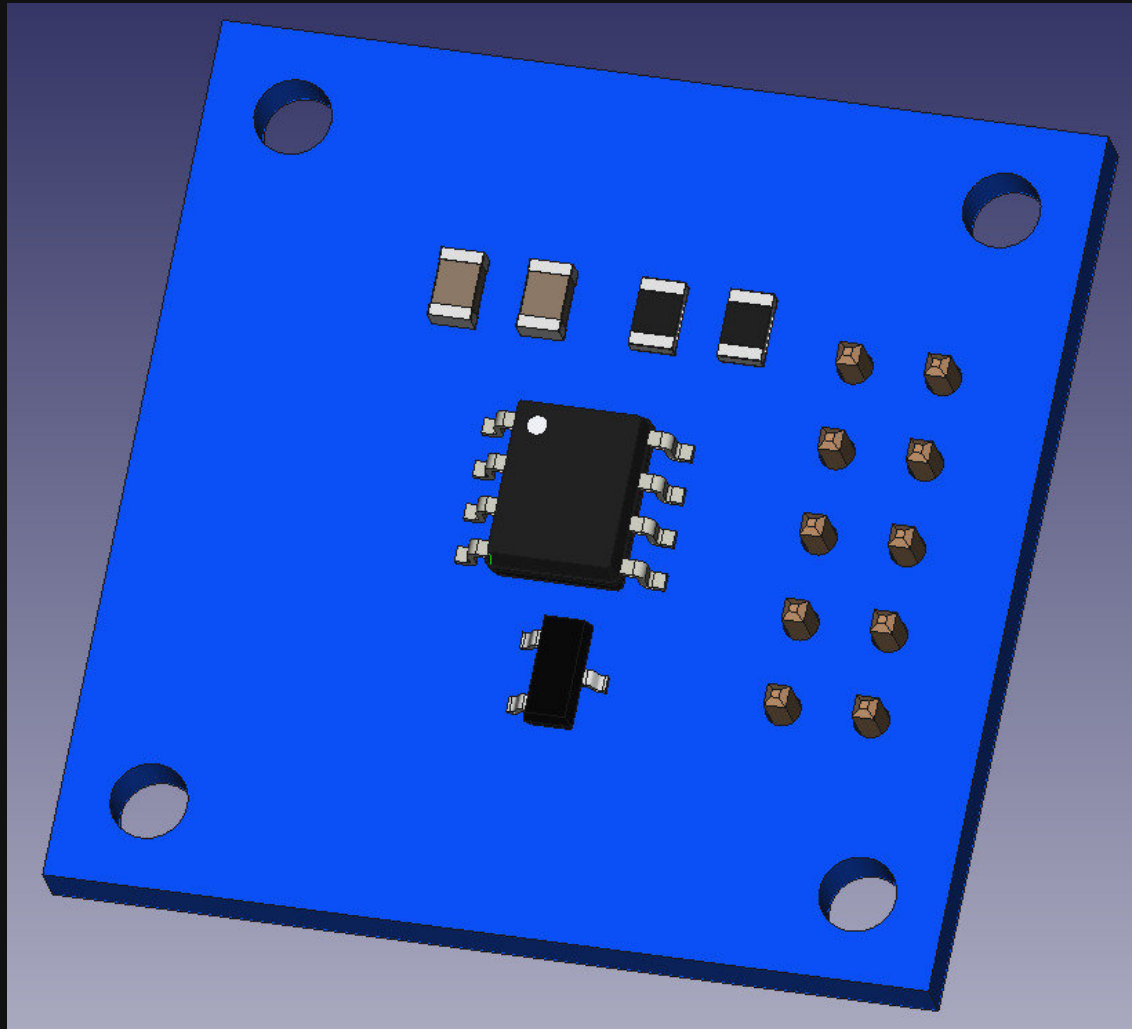
- Open hardware, 3D printable rotator design



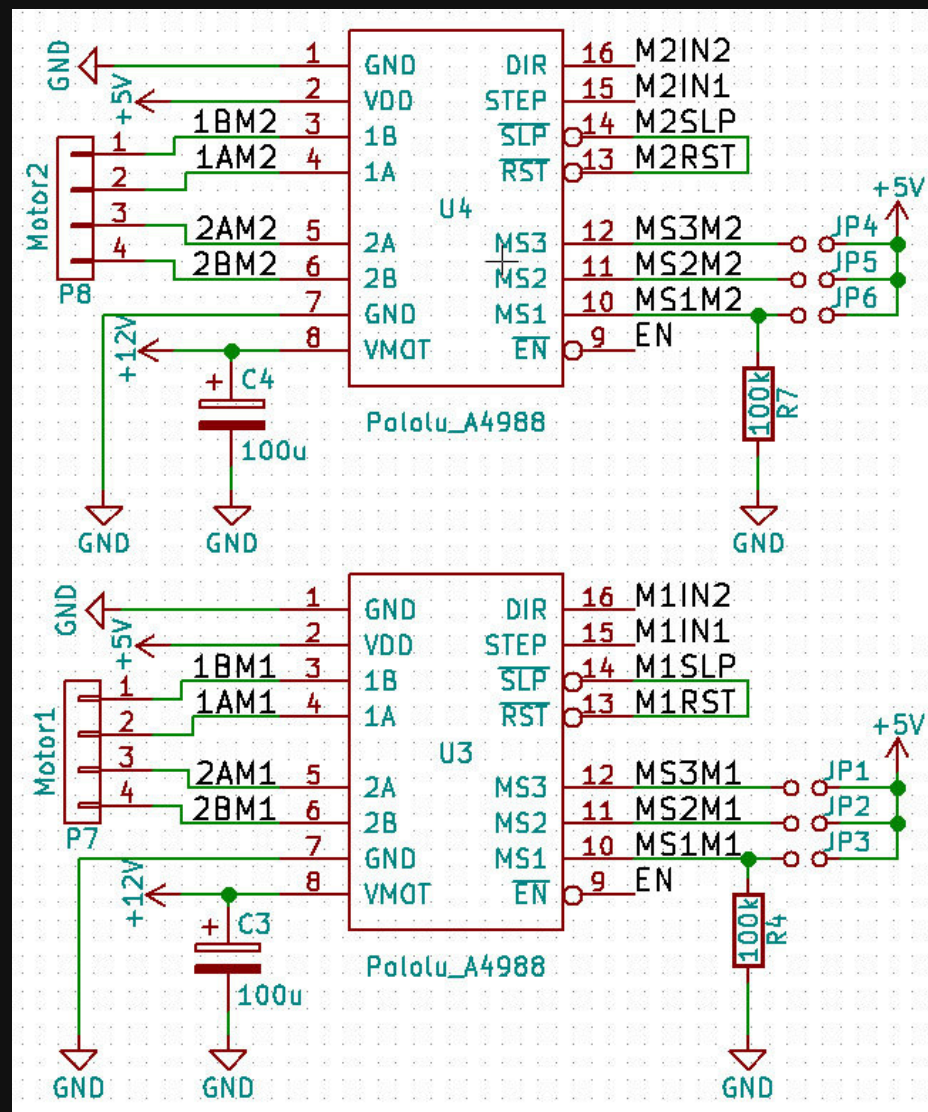
7

Second axis side on frame

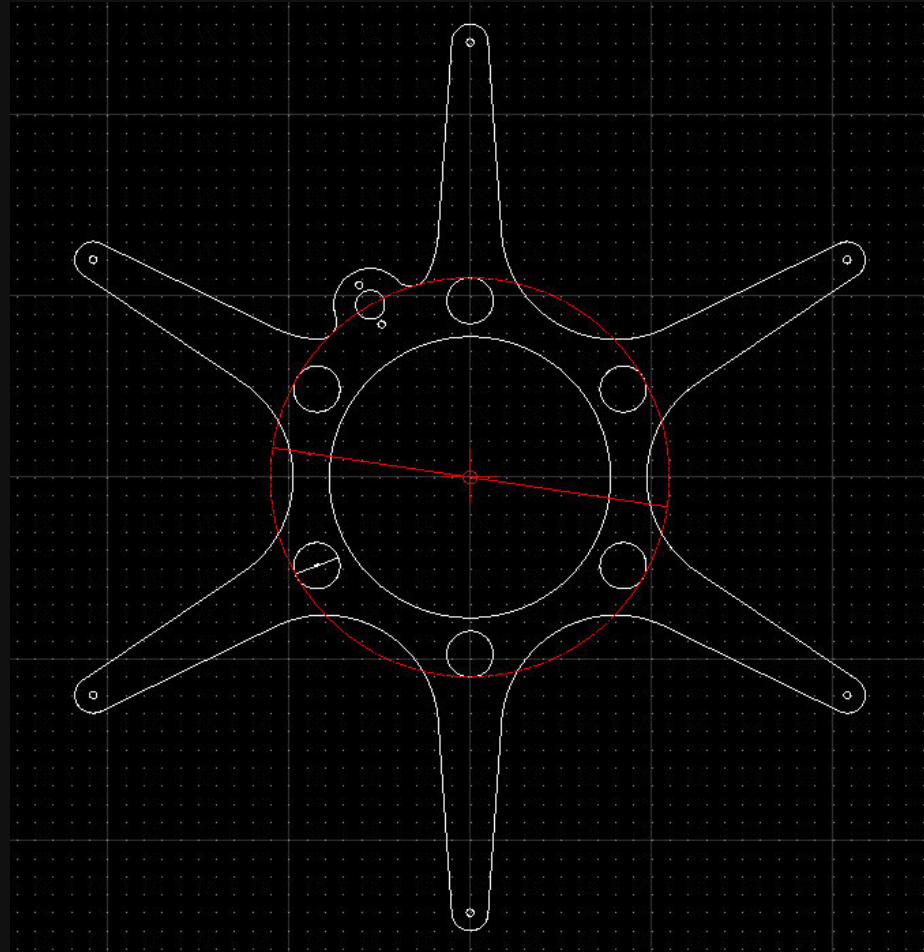




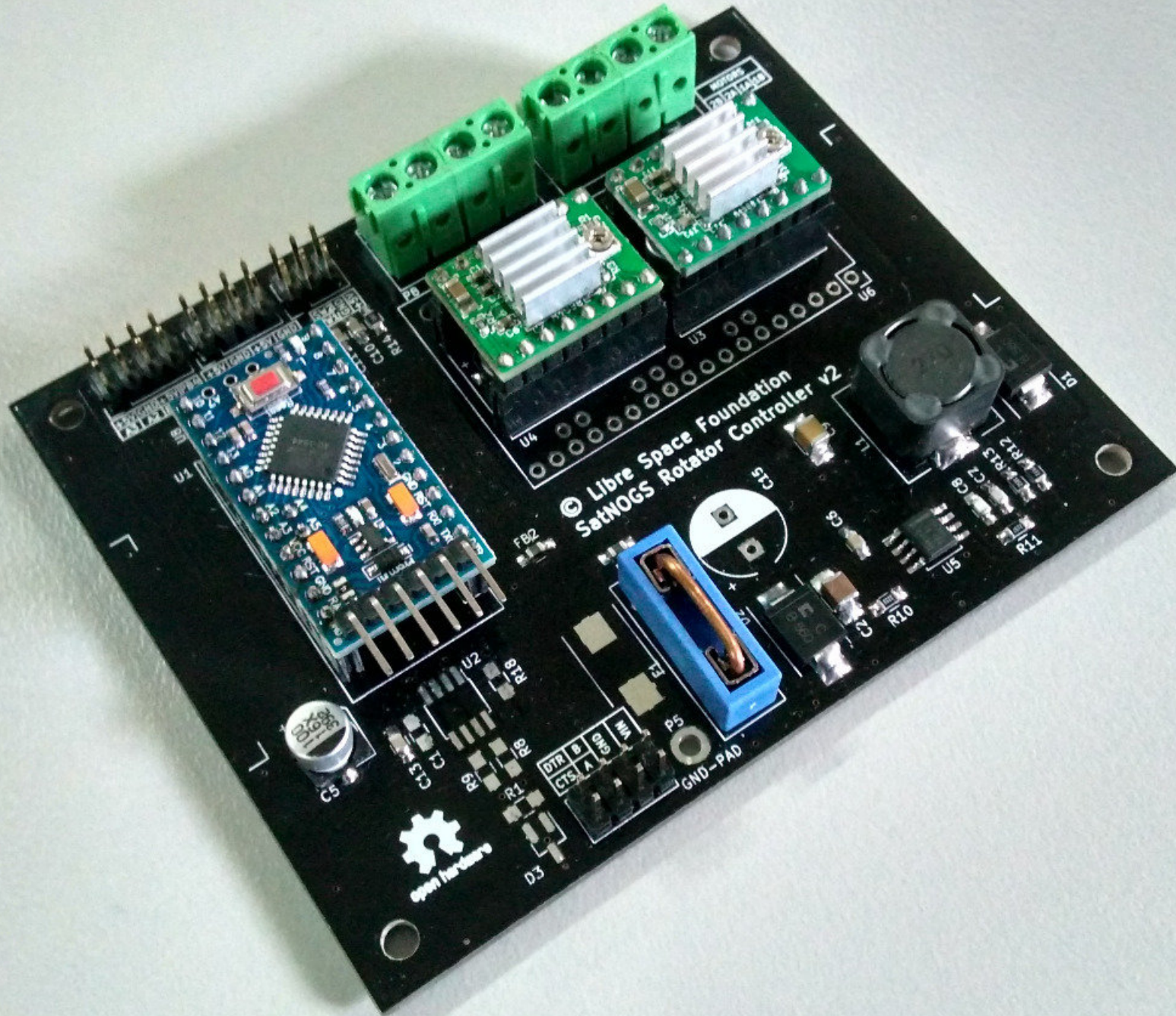
FreeCAD



KiCad



QCad



Ground Station

Reference platform: Raspberry
Pi3 + rtl-sdr

Works with any SDR
supported by gr-osmosdr

Client runs on any Linux
platform - Python & Gnuradio

LNA highly recommended,
LNA4ALL or others

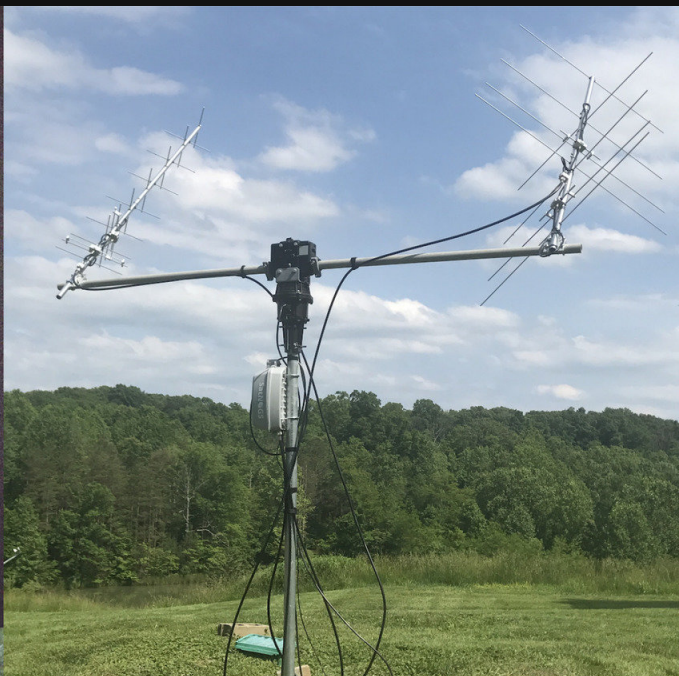
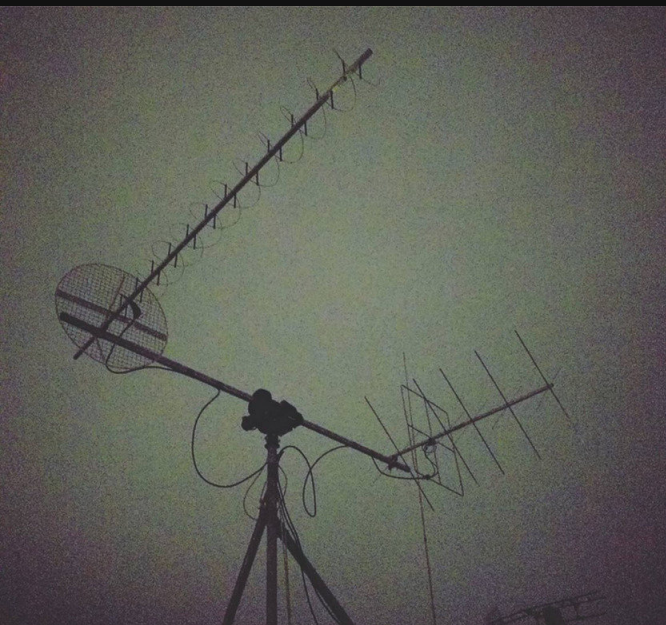


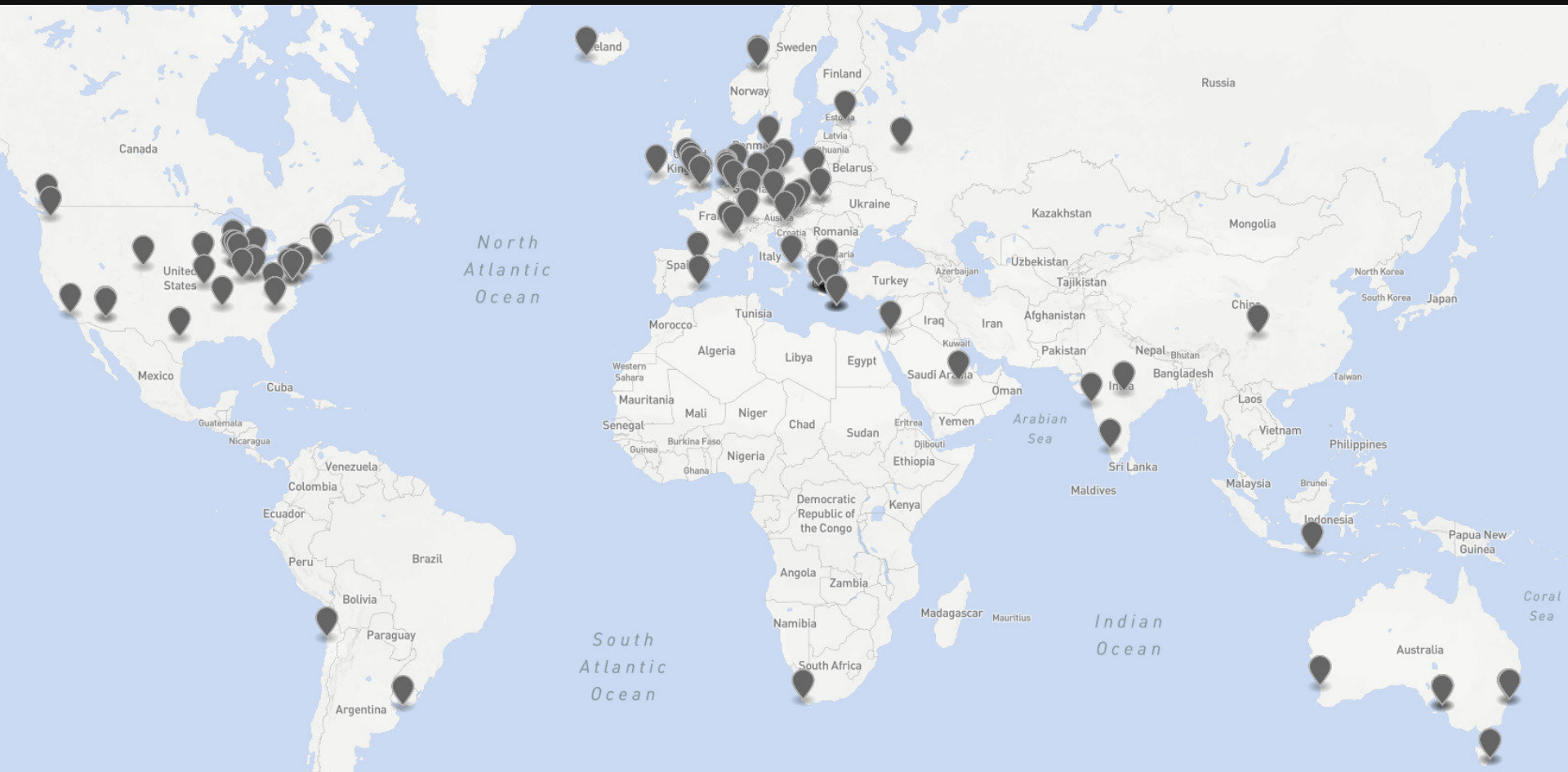
Gitlab CI

PiGen

Ansible

```
1  image: docker:latest
2  services:
3    - docker:dind
4  before_script:
5    - apk --update add bash
6  default:
7    stage: build
8  script:
9    - echo "IMG_NAME='Raspbian-SatNOGS-${CI_COMMIT_REF_NAME}'" > config
10   - touch ./stage3/SKIP ./stage4/SKIP ./stage5/SKIP
11   - rm stage4/EXPORT*
12   - bash build-docker.sh
13   - (cd deploy; sha256sum *.info image*.zip > sha256sums)
14  except:
15    - tags
16  artifacts:
17    expire_in: 4 weeks
18    paths:
19      - deploy/*.info
20      - deploy/image*.zip
21      - deploy/sha256sums
22  release:
23    stage: build
24    script:
25      - echo "IMG_NAME='Raspbian-SatNOGS'" > config
26      - touch ./stage3/SKIP ./stage4/SKIP ./stage5/SKIP
27      - rm stage4/EXPORT*
28      - bash build-docker.sh
29      - (cd deploy; sha256sum *.info image*.zip > sha256sums)
30  only:
31    - tags
32  artifacts:
33    paths:
34      - deploy/*.info
35      - deploy/image*.zip
36      - deploy/sha256sums
```



DB

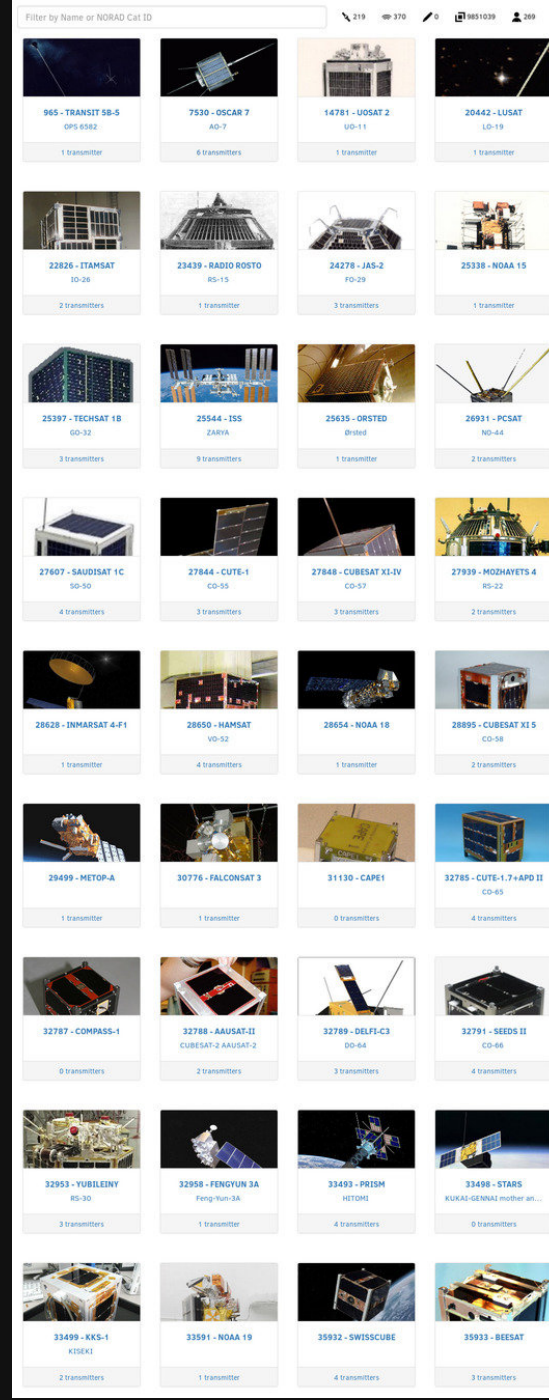
db.satnogs.org

Crowd-sourced satellite database

- status, frequencies, info

Repository for collected telemetry data

- API that works with 3rd party apps
 - DK3WN TLM Forwarder
 - Gr-satellites sids forwarder
 - Gpredict
- Download collected data
- To date: ~10M frames from 80 satellites



```
def find_sync_index(data):  
    sync_bytes = bytearray([0x55, 0x53, 0x36]) # U S 6 or 0x55 0x53 0x36  
    packet_start_index = bytearray(data).find(sync_bytes)  
    return packet_start_index  
  
payload = bytearray.fromhex(payload)  
sync_offset = find_sync_index(payload)  
  
if sync_offset == -1:  
    raise ValueError('No sync bytes found')  
else:  
    payload = payload[sync_offset:len(payload)]
```



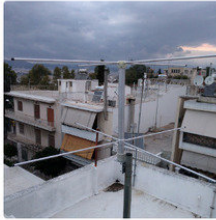
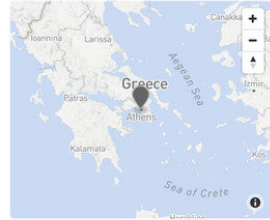
Network

network.satnogs.org

- Schedule observations, managing available/capable ground stations
- Collects and displays results from observations when finished
 - Waterfalls
 - Demodulated audio
 - Demodulated data

7 - Stony

Owner: Nikos Roussos
QTH Locator: KM17ux
Coordinates: 37.970°, 23.714°
Altitude: 65 m
Min Horizon: 25°
Antennas: VHF Tunable
Success Rate:
Observations: 2754 [View all](#)
Creation Date: 7 months, 3 weeks ago
Online: Last seen 0 minutes ago



Pass predictions

[Include unsupported satellites](#)

Name	Timeframe	↑ Rise*	→ Max*	↓ Set*	Polar	
41600 - SATHYABASAT	2017-12-23 20:19:54 2017-12-23 20:31:03	↑ 193°	→ 25°	↓ 335°		schedule ↗
41557 - NUSAT 1	2017-12-23 20:54:41 2017-12-23 21:06:07	↑ 167°	→ 89°	↓ 349°		schedule ↗
40719 - DEORBITSAIL	2017-12-23 20:55:58 2017-12-23 21:09:33	↑ 15°	→ 64°	↓ 186°		schedule ↗
42761 - CAS-4A	2017-12-23 20:57:17 2017-12-23 21:10:06	↑ 290°	→ 48°	↓ 94°		schedule ↗
42759 - CAS-4B	2017-12-23 21:11:37 2017-12-23 21:24:29	↑ 291°	→ 53°	↓ 98°		schedule ↗
40032 - QB50P2	2017-12-23 21:47:29 2017-12-23 22:00:11	↑ 22°	→ 33°	↓ 173°		schedule ↗
41466 - SAMSAT-218D	2017-12-23 21:59:19 2017-12-23 22:10:28	↑ 7°	→ 58°	↓ 201°		schedule ↗
40024 - NANOSATC-BR1	2017-12-23 22:08:10 2017-12-23 22:21:04	↑ 19°	→ 45°	↓ 180°		schedule ↗
41732 - 3CAT-2	2017-12-23 22:13:33 2017-12-23 22:25:03	↑ 20°	→ 37°	↓ 176°		schedule ↗
40025 - QB50P1	2017-12-23 22:30:30 2017-12-23 22:43:36	↑ 11°	→ 83°	↓ 196°		schedule ↗
42761 - CAS-4A	2017-12-23 22:37:34 2017-12-23 22:50:23	↑ 291°	→ 57°	↓ 126°		schedule ↗
42759 - CAS-4B	2017-12-23 22:51:53 2017-12-23 23:04:36	↑ 290°	→ 46°	↓ 131°		schedule ↗



New Observation



🕒 Timeframes are in [UTC](#)

Satellite

33591 - NOAA 19

Transmitter

APT Downlink - 137.100 MHz - APT

Using TLE 999 issued 6 hours, 56 minutes ago

Start Time

2017-12-23 20:18



End Time

2017-12-23 21:18



Calculate

Calculated Timeline

12 - W2BFJ

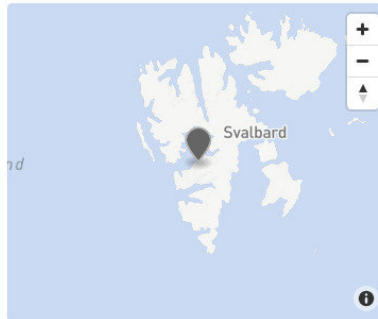
27 - NB3T - VHF



Schedule

133 - SOSA-svalbard

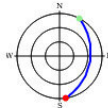
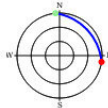
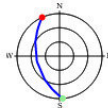
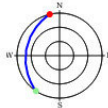
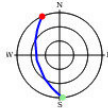
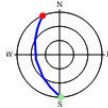
Owner	kapjp
QTH Locator	JQ78tf
Coordinates	78.223°, 15.656°
Altitude	5 m
Min Horizon	10°
Antennas	UHF Turnstile
Observations	18 View all
Creation Date	4 months, 1 week ago
Offline	Last seen 3 months, 2 weeks ago



Slovak Organisation for Space Activities polar GS

Pass predictions

▼ Include unsupported satellites

Name	Timeframe	↑ Rise°	↔ Max°	↓ Set°	Polar	
40380 - EXOCUBE	2017-12-23 19:31:43 2017-12-23 19:42:06	↑ 28°	↔ 24°	↓ 172°		schedule 
40042 - POLYTAN-1	2017-12-23 19:33:00 2017-12-23 19:43:16	↑ 355°	↔ 10°	↓ 99°		schedule 
42792 - ROBUSTA-1B	2017-12-23 19:33:13 2017-12-23 19:44:58	↑ 176°	↔ 41°	↓ 336°		schedule 
40928 - TIANWANG 1A	2017-12-23 19:33:16 2017-12-23 19:43:39	↑ 214°	↔ 18°	↓ 347°		schedule 
42790 - VZLUSAT-1	2017-12-23 19:33:23 2017-12-23 19:45:08	↑ 176°	↔ 41°	↓ 336°		schedule 
42768 - LITUANICASAT-2	2017-12-23 19:38:01 2017-12-23 19:49:49	↑ 178°	↔ 39°	↓ 337°		schedule 

Observation #28747

🕒 Timeframes are in UTC

Satellite

28654 - NOAA 18

Station

22 - Ferns-1

Observer

Dimitrios Papadeas

Status

Verified

Transmitter

APT Downlink

Frequency

137.912 MHz

Encoding

APT

Timeframe

2017-11-07 14:29:12
2017-11-07 14:44:32

Rise

6.0°

Max

36.0°

Set

221.0°

Downloads

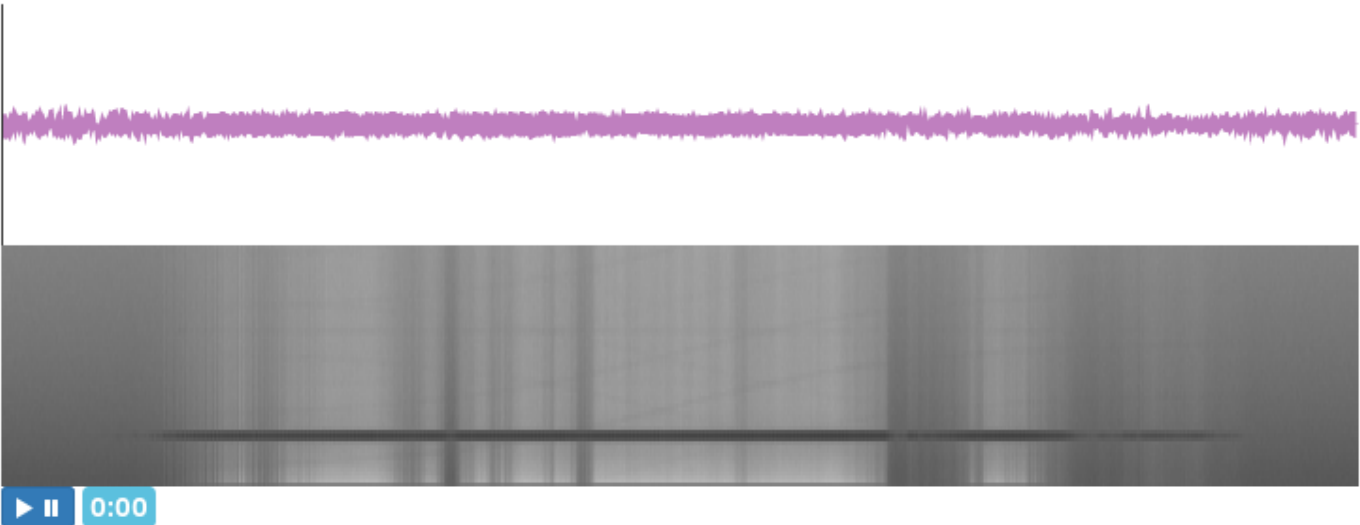
🔊 Audio

🌊 Waterfall

Waterfall

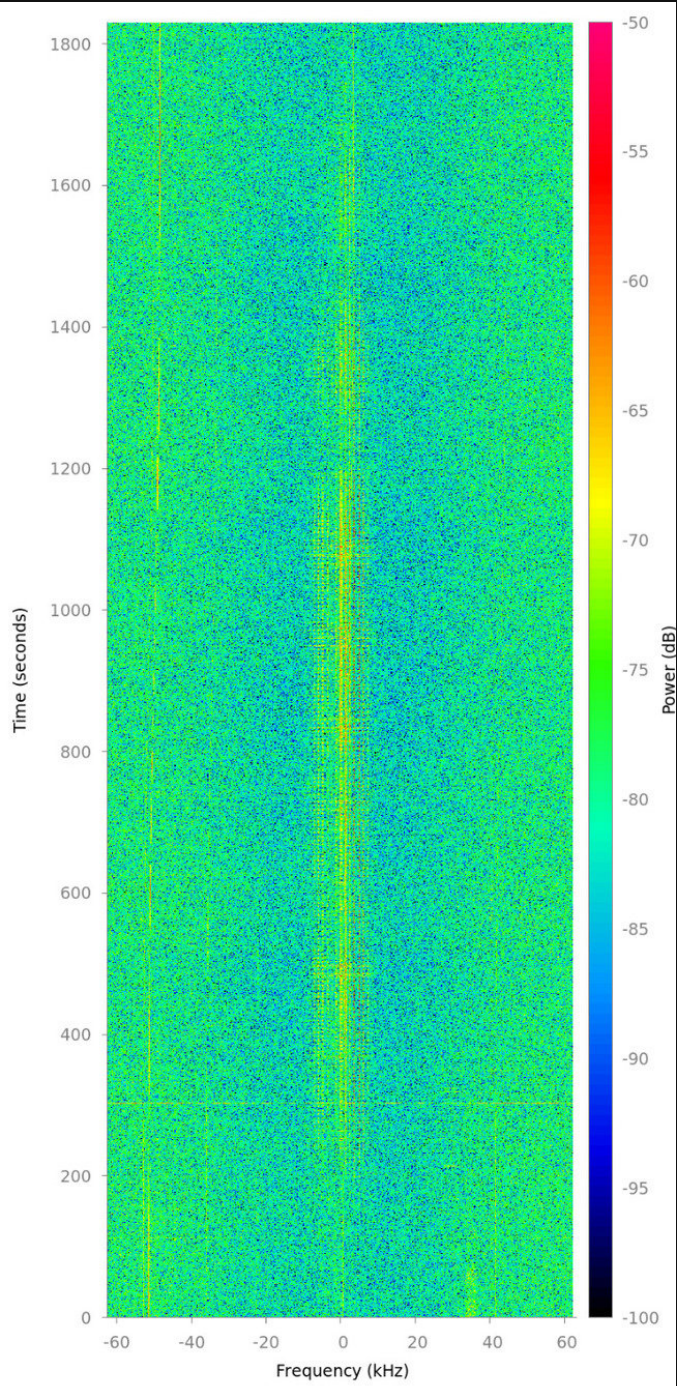
Audio

Data 1



TLE used by Celestrak

```
1 28654U 05018A 17310.87439481 .000000013 00000-0 32416-4 0 9999
2 28654 99.1721 336.5069 0014779 35.0416 325.1724 14.12355880642301
```

```
@app.task
def archive_audio(id):
    obs = Observation.objects.get(id=id)
    identifier = 'satnogs-observation-{0}'.format(obs.id)
    if os.path.isfile(obs.payload.path):
        ogg = obs.payload.path
        filename = obs.payload.name.split('/')[-1]
        md = dict(collection=settings.ARCHIVE_COLLECTION,
                  title=identifier,
                  mediatype='audio')
        res = upload(identifier, files=[ogg], metadata=md,
                     access_key=settings.S3_ACCESS_KEY,
                     secret_key=settings.S3_SECRET_KEY)
```



Client

- Checks in with the network regularly
- When a job is scheduled
 1. Commands the rotator
 2. Starts a gnuradio script to collect RF
 3. Adjusts frequency for doppler correction
 4. Generates a waterfall, audio, etc.
 5. Uploads the results
- Comes in source, packages or a ready-to-flash RPi3 image
- Web-interface with stand-alone abilities (for TX/RX too)

Ground station

ID 7 Coordinates 38.0-23.7 Altitude 65.0 Azimuth - Elevation - Frequency -

Scheduled observations ▾

ID	Satellite	Frequency	Encoding	Timeframe
50914	NOAA 19	137100000	APT	2017-12-24T13:46:30Z-2017-12-24T14:02:27Z
50915	XW-2C	145790315	CW	2017-12-24T15:08:53Z-2017-12-24T15:20:28Z
50916	KAITUO 1B	145475000	GMSK9k6	2017-12-24T15:37:17Z-2017-12-24T15:49:08Z
50917	XW-2D	145855000	CW	2017-12-24T15:58:10Z-2017-12-24T16:10:14Z

Terminal

```
u'start': u'2017-12-24T16:41:44Z', u'frequency': 137912500, u'mode': u'APT', u'id': 51424, u'ground_station': 7)
15:22:19 [INFO]: Adding new job: 50918
15:22:19 [DEBUG]: Observation obj: {'baud': None, 'origin': 'network', u'transmitter': u'HRxEBxwoWJDuuVF5CfiyET', u'end': u'2017-12-24T16:26:28Z', u'tle2': u'2 40911
97.4584 358.9347 0012804 280.7089 79.2702 15.15021388124718', u'tle1': u'1 40911U 15049N 17356.95687218 .00000819 00000-0 47283-4 0 9998', u'tle0': u'XW-2B',
u'start': u'2017-12-24T16:14:40Z', u'frequency': 145725000, u'mode': u'CW', u'id': 50918, u'ground_station': 7}
15:22:19 [INFO]: Adding new job: 50917
15:22:19 [DEBUG]: Observation obj: {'baud': None, 'origin': 'network', u'transmitter': u'V76m6YW7nVsTrgCboMVHEb', u'end': u'2017-12-24T16:10:14Z', u'tle2': u'2 40907
97.4545 358.7163 0012886 279.2008 80.7767 15.15070680124850', u'tle1': u'1 40907U 15049J 17357.20965830 .00000826 00000-0 47628-4 0 9992', u'tle0': u'XW-2D',
u'start': u'2017-12-24T15:58:10Z', u'frequency': 145855000, u'mode': u'CW', u'id': 50917, u'ground_station': 7}
15:22:19 [INFO]: Adding new job: 50916
15:22:19 [DEBUG]: Observation obj: {'baud': 9600.0, 'origin': 'network', u'transmitter': u'EifSE4XNdP9LYoFNcbNJo', u'end': u'2017-12-24T15:49:08Z', u'tle2': u'2 40912
97.4505 2.0857 0013581 264.3275 159.9479 15.18314521124964', u'tle1': u'1 40912U 15049P 17357.20970116 .00001797 00000-0 90724-4 0 9994', u'tle0': u'KAITUO 1B',
u'start': u'2017-12-24T15:37:17Z', u'frequency': 145475000, u'mode': u'GMSK9k6', u'id': 50916, u'ground_station': 7}
15:22:19 [INFO]: Adding new job: 50915
15:22:19 [DEBUG]: Observation obj: {'baud': None, 'origin': 'network', u'transmitter': u'jXXaGaB5LzZEurn8XGtMYF', u'end': u'2017-12-24T15:20:28Z', u'tle2': u'2 40906
97.4573 358.7657 0013547 282.2631 77.7084 15.14938218124812', u'tle1': u'1 40906U 15049H 17356.97655498 .00000772 00000-0 44915-4 0 9996', u'tle0': u'XW-2C',
u'start': u'2017-12-24T15:08:53Z', u'frequency': 145790315, u'mode': u'CW', u'id': 50915, u'ground_station': 7}
15:22:19 [INFO]: Adding new job: 50914
15:22:19 [DEBUG]: Observation obj: {'baud': None, 'origin': 'network', u'transmitter': u'kE4VaYKpnFmzEquEjKKi8D', u'end': u'2017-12-24T14:02:27Z', u'tle2': u'2 33591
99.1196 326.6925 0014916 100.8691 259.4159 14.12239593457030', u'tle1': u'1 33591U 09005A 17356.94258950 .00000090 00000-0 74061-4 0 9990', u'tle0': u'NOAA 19',
u'start': u'2017-12-24T13:46:30Z', u'frequency': 137100000, u'mode': u'APT', u'id': 50914, u'ground_station': 7}
15:23:27 [INFO]: Status view initiated
15:23:27 [INFO]: Received mode change: {'custom_cmd': {'mode': 'network'}}
15:24:15 [INFO]: Get jobs started
15:24:15 [DEBUG]: URL: https://network.satnogs.org/api/jobs/
15:24:16 [DEBUG]: Params: {'ground_station': 7}
15:24:16 [DEBUG]: Headers: {'Authorization': 'Token 1ef021f7e2b8179ce492a07905251da04134bec1'}
```



Logging info is lost after page refresh

UPSat C&C

Serial

Test

Time

Power

Mass Storage

House keeping

ADCS TLE

Comms

Schedule

mNLP

Custom

Function:

Set time in UTC

Destination:

UMB

Application ID:

OBC

Time:

22-06-2016 12:01:00



Send

Terminal

```
22. June 2016 15:08:06 obc 1265.605 comms 3203.144 eps
382.862 adcs 0.0 task_uart 1259.039 task_idle 1265.039 task_hk
1206.587 task_su 0.0 task_sch 1265.075 vbat 1878 su_ser_state
0 su_scpt_sch 1

21:10:41 > OBC ECSS command send
21:10:45 < OBC ACK OK
21:12:35 < OBC HK EXT WOD time 519912602 UTC Wednesday,
22. June 2016 15:10:02 obc 1325.633 comms 3368.51 eps
389.778 adcs 0.0 task_uart 1319.04 task_idle 1325.04 task_hk
1266.615 task_su 0.0 task_sch 1325.076 vbat 1875 su_ser_state
0 su_scpt_sch 1

21:13:55 < OBC HK EXT WOD time 519912679 UTC Wednesday,
22. June 2016 15:11:19 obc 1385.661 comms 3483.782 eps
403.055 adcs 0.0 task_uart 1379.041 task_idle 1385.041 task_hk
1326.643 task_su 0.0 task_sch 1385.077 vbat 1876 su_ser_state
0 su_scpt_sch 1

21:14:16 > OBC ECSS command send
21:14:25 < OBC ACK Error SATR_PKT_INIT
21:15:25 < OBC HK EXT WOD time 519912770 UTC Wednesday,
22. June 2016 15:12:50 obc 65.118 comms 3593.167 eps
415.661 adcs 0.0 task_uart 59.118 task_idle 64.118 task_hk 6.002
task_su 0.0 task_sch 64.161 vbat 1878 su_ser_state 1
su_scpt_sch 1

21:16:25 < OBC HK EXT WOD time 519912831 UTC Wednesday,
22. June 2016 15:13:51 obc 125.147 comms 3653.193 eps
422.577 adcs 0.0 task_uart 119.12 task_idle 125.12 task_hk
66.128 task_su 0.0 task_sch 124.163 vbat 1875 su_ser_state 1
su_scpt_sch 1
```



backend reported a few seconds ago

WOD

Contribute!

- Setup a station! - wiki.satnogs.org
- Contribute to db.satnogs.org
- Write some code (C, C++, Python, JS)
- Help with documentation
- Help with testing and automation
- Join our channel [#satnogs:matrix.org](https://matrix.org) | freenode.net

Thank You!

Nikos Roussos

[@comzeradd](#)

nikos@libre.space