

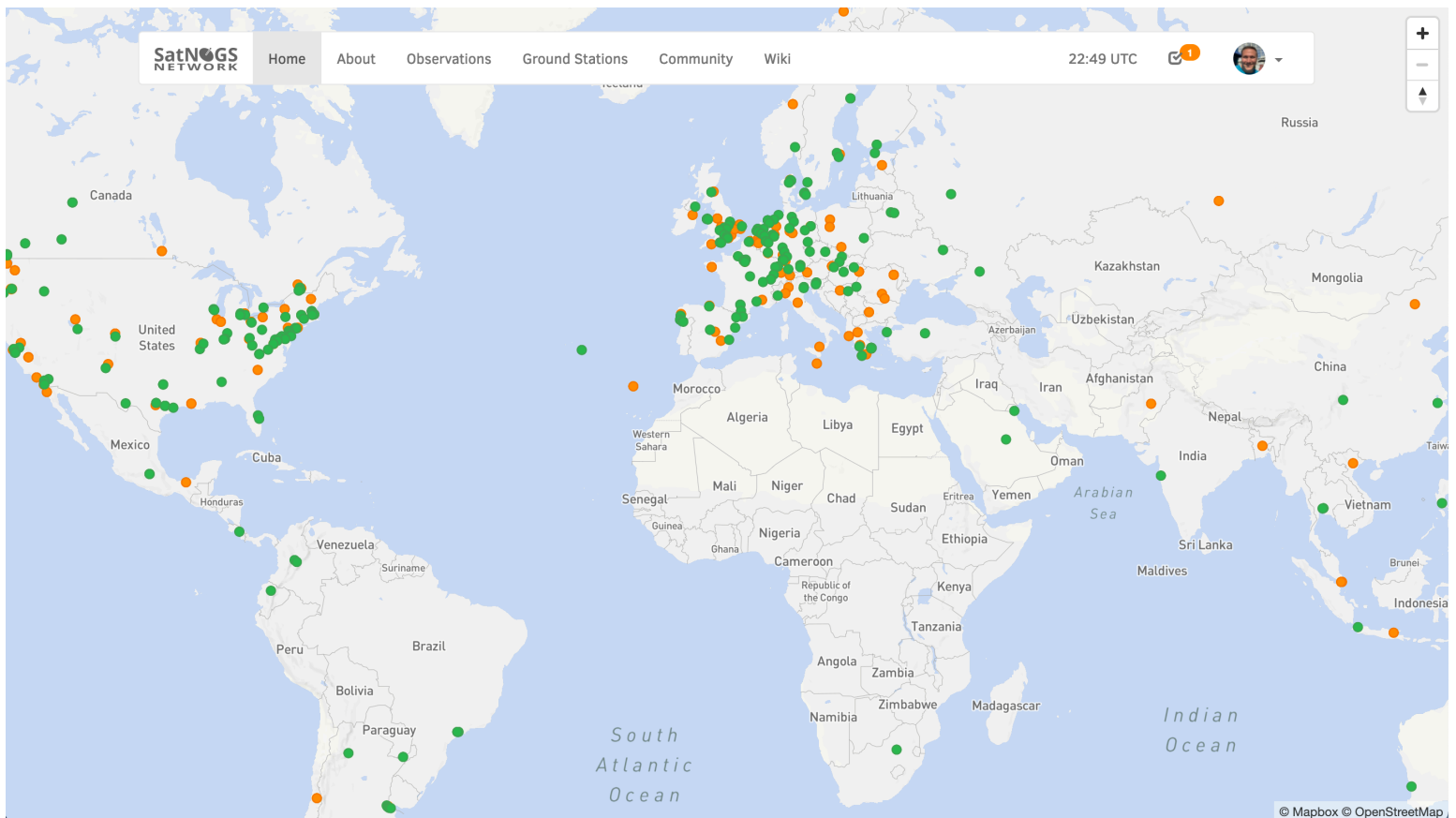


# I Hunt Satellites

Crowdsourced satellite telemetry collection with SatNOGS

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2021 CubeSat Developers Workshop



## What is SatNOGS?

SatNOGS (Satellite Networked Open Ground Station) is a collection of projects and a global community of contributors working to improve the collection of data from satellites. We accomplish this through the automation of data collection and processing via software, while driving the cost of building and operating a ground station down through Open Hardware projects.

SatNOGS is an Open Source development community, driven by a global team of volunteers, and backed by the Libre Space Foundation ([libre.space](https://libre.space)).

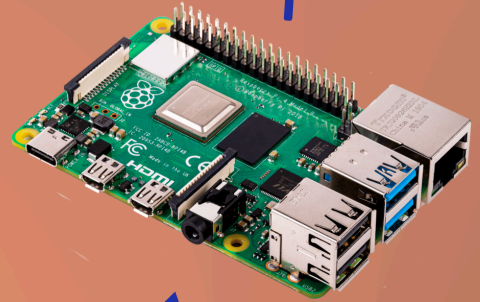
We are driven by the free and open exchange of data about Satellites, from Satellites, and contributing to the development and operation of Satellites. For this reason we focus on collecting data from Satellites that operate (mostly) in the Amateur Radio spectrum and that adhere to international frequency use and coordination. All data collected and results processed by the SatNOGS project is free for use with a Creative Commons license.

We welcome CubeSat operators to work with us as a ground station resource, and expect similar transparency and knowledge-sharing from the operators about their missions and lessons to be learned.



## Following the data - CubeSat to dashboard

We're going to take a little trip from the perspective of a CubeSat being tracked and monitored in the SatNOGS network:



## SatNOGS Client & Ground Stations

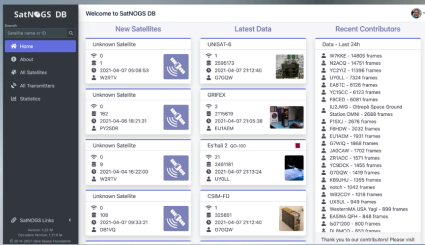
The first step is the Radio Frequency (RF) reception and handling. The SatNOGS client is designed to run on a Raspberry Pi and we provide an image to get a station up and running quickly. Our client is modular by design, working with a wide range of Software Defined Radio (SDR) devices and receiving antennas, fixed and rotational.

The client uses GNURadio to do most of the work in demodulating and decoding the signal. Doppler shift is compensated for constantly by the client. If there is an antenna rotator involved, the client will also send commands to the rotator interface to keep the antennas on track with the position of the satellite.

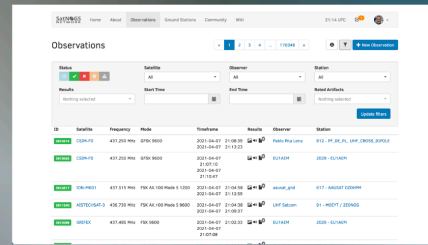
The client produces a number of artifacts, typically including:

- RF Waterfall image
- Compressed audio of the demodulated RF
- Any data decoded from the observation (TLM frames, imagery, etc)

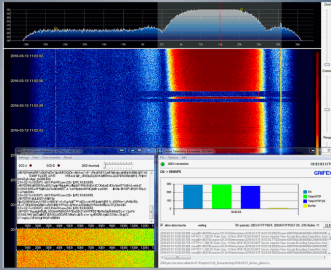
These artifacts are uploaded automatically to our Command and Control system, the SatNOGS Network...



SatNOGS DB  
Sat details and data - [db.satnogs.org](http://db.satnogs.org)



SatNOGS Network  
Ground Station C&C - [network.satnogs.org](http://network.satnogs.org)



Third-party Sources  
Prezi, 3W, gr-satellites



SatNOGS Dashboard  
TLM Data Visualization - [dashboard.satnogs.org](http://dashboard.satnogs.org)

## SatNOGS Web Services

There are a lot of web based services in the SatNOGS ecosystem that help in collecting data and making use of it. In this presentation we will cover the services that are most impactful in our data processing path.

SatNOGS NETWORK Home About Observations Ground Stations Community Wiki 21:14 UTC

Observations < 1 2 3 4 ... 170348 > + New Observation

Status: [Icons] Satellite: All Observer: All Station: All

Results: Nothing selected Start Time: End Time: Rated Artifacts: Nothing selected

Update filters

ID	Satellite	Frequency	Mode	Timeframe	Results	Observer	Station
3914516	CSIM-FD	437.250 MHz	GFSK 9600	2021-04-07 21:08:39 2021-04-07 21:13:23	[Icons]	Pablo Pita Leira	812 - PF_DE_PL_UHF_CROSS_DIPOLE
3913043	CSIM-FD	437.250 MHz	GFSK 9600	2021-04-07 21:07:10 2021-04-07 21:10:47	[Icons]	EU1AEM	2029 - EU1AEM
3914517	ION-MK01	437.515 MHz	FSK AX.100 Mode 5 1200	2021-04-07 21:04:58 2021-04-07 21:12:59	[Icons]	aausat_gnd	617 - AAUSAT OZ0HPM
3911240	AISTECHSAT-3	436.730 MHz	FSK AX.100 Mode 5 9600	2021-04-07 21:04:38 2021-04-07 21:09:37	[Icons]	UHF Satcom	91 - M0EYT / 2EQNOG
3913098	GRIFEX	437.485 MHz	FSK 9600	2021-04-07 21:02:33 2021-04-07 21:07:08	[Icons]	EU1AEM	2029 - EU1AEM

# SatNOGS Network

## Ground Station C&C - [network.satnogs.org](http://network.satnogs.org)



## SatNOGS Network

The SatNOGS Network is the control hub for ground station clients (the raspberry pi and sdr devices mentioned earlier). From here, anyone can sign up for an account and create an entry for their ground station. With their API key and details entered back into the SatNOGS client, the client will begin checking in to the network for observation tasks to run.

In the network, an operator can schedule Satellite observations for a single ground station or for a time span across multiple ground stations (depending on availability). With no other requests for observations scheduled, we have an auto scheduling system that will make the best use of ground station resources across the network.

Individual observation results are collected here and you can view the RF waterfall image, play demodulated audio, or download the artifacts directly.

Decoded telemetry frames for supported Satellites are uploaded to the SatNOGS DB...

# SatNOGS DB

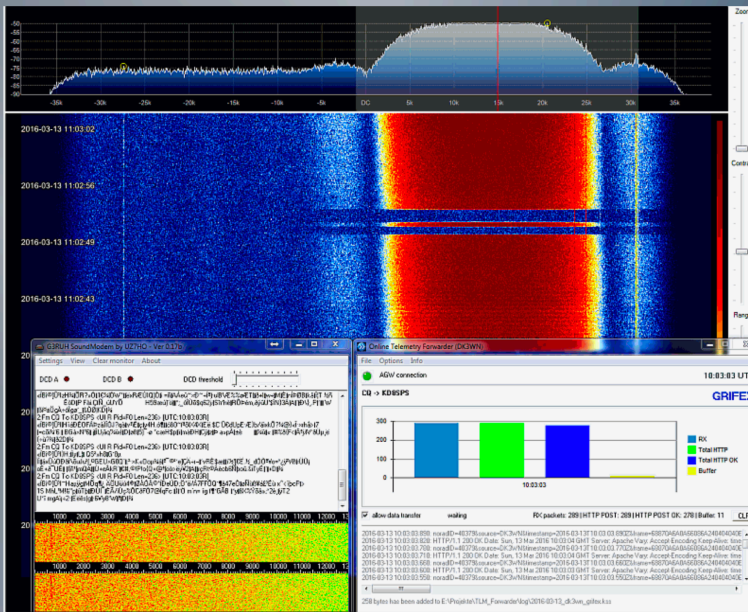
Sat details and data - [db.satnogs.org](https://db.satnogs.org)



## SatNOGS DB

The SatNOGS DB is a crowdsourced repository of Satellite information and database for telemetry frames. From here, a user can find mission information about a Satellite, frequencies and RF modes, status, and view a map. (We are always looking for editorial help in keeping the details up to date!)

Telemetry frames that are uploaded to SatNOGS DB are typically in a hexadecimal state (the raw frame itself). We make use of kaitai structs ([kaitai.io](https://kaitai.io)) to build telemetry decoders that can then decode the raw frames into usable telemetry data. In the end these decoded data fields are uploaded to a time series database to be used in dashboards and other means.



# Third-party Sources

## DK3WN, gr-satellites

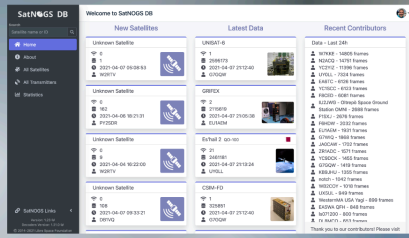


## SatNOGS DB - Third-party Sources

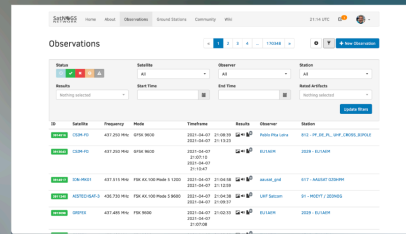
We collect raw telemetry frames from third party sources as well, most notably the suite of satellite decoding applications from Mike Rupprecht DK3WN, and the gnuradio module gr-satellites from Daniel Estévez EA4GPZ.

Once these frames are in the SatNOGS DB, they are further decoded into telemetry fields the same as the frames that were collected from SatNOGS Network.

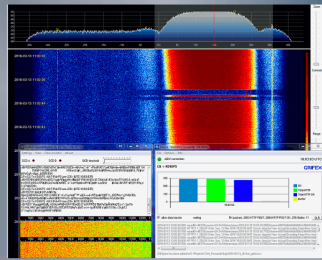




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SatNOGS Network  
Ground Station C&C -  
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Third-party Sources  
Prezi, K3WN, gr-satellites



SatNOGS Dashboard  
TLM Data Visualization -  
[dashboard.satnogs.org](http://dashboard.satnogs.org)

## Using the Telemetry Data

So far we have collected, uploaded, processed, and passed the data across multiple services. Where telemetry data is concerned it has not been very useful yet.

After the SatNOGS Decoders turn the raw telemetry frames into telemetry fields in a time-series database, the end result is our dashboard service..

# SatNOGS Dashboard

## TLM Data Visualization - [dashboard.satnogs.org](https://dashboard.satnogs.org)

Prezi

## SatNOGS Dashboard

The Dashboard service is a Grafana instance to provide dashboard creation across a wide range of query possibilities from the decoded data frames. This is a dynamic application allowing the time of view to change quickly and easily.

As with the rest of the SatNOGS project, this is crowd-sourced and open to contribution from anyone and everyone. Sign in and create your own dashboards from existing CubeSat data, or work with us on designing a mission dashboard for your upcoming launch!

While our coverage varies with ground station availability and the overall growth of the project and increasing number of launches, I am continually impressed with the amount of data we are able to collect and use in this manner. As for processing time, if a ground station is in the middle of an observation for a CubeSat we have decoding support for, the time to go from RF beacon to the dashboard above can be as low as 5-10 minutes, regardless of where that observation is taking place around the globe.

## Get involved!

Libre Space Foundation - <https://libre.space>

Forums - <https://community.libre.space>

Chat - #satnogs on matrix.org

SatNOGS DB - <https://db.satnogs.org>

SatNOGS Network - <https://network.satnogs.org>

SatNOGS Dashboard - <https://dashboard.satnogs.org>

Wiki - <https://wiki.satnogs.org>

Code - <https://gitlab.org/librespacefoundation>

**Thanks for your time! Corey Shields - [cshields@libre.space](mailto:cshields@libre.space)**



We are a passionate global group of space and satellite enthusiasts, and are always welcome to help across a wide range of contributions, including code development (python, javascript, gnuradio, [kaitai.io](http://kaitai.io)), documentation, forum support, and editorial help on DB.

I hope to see some of you online soon!