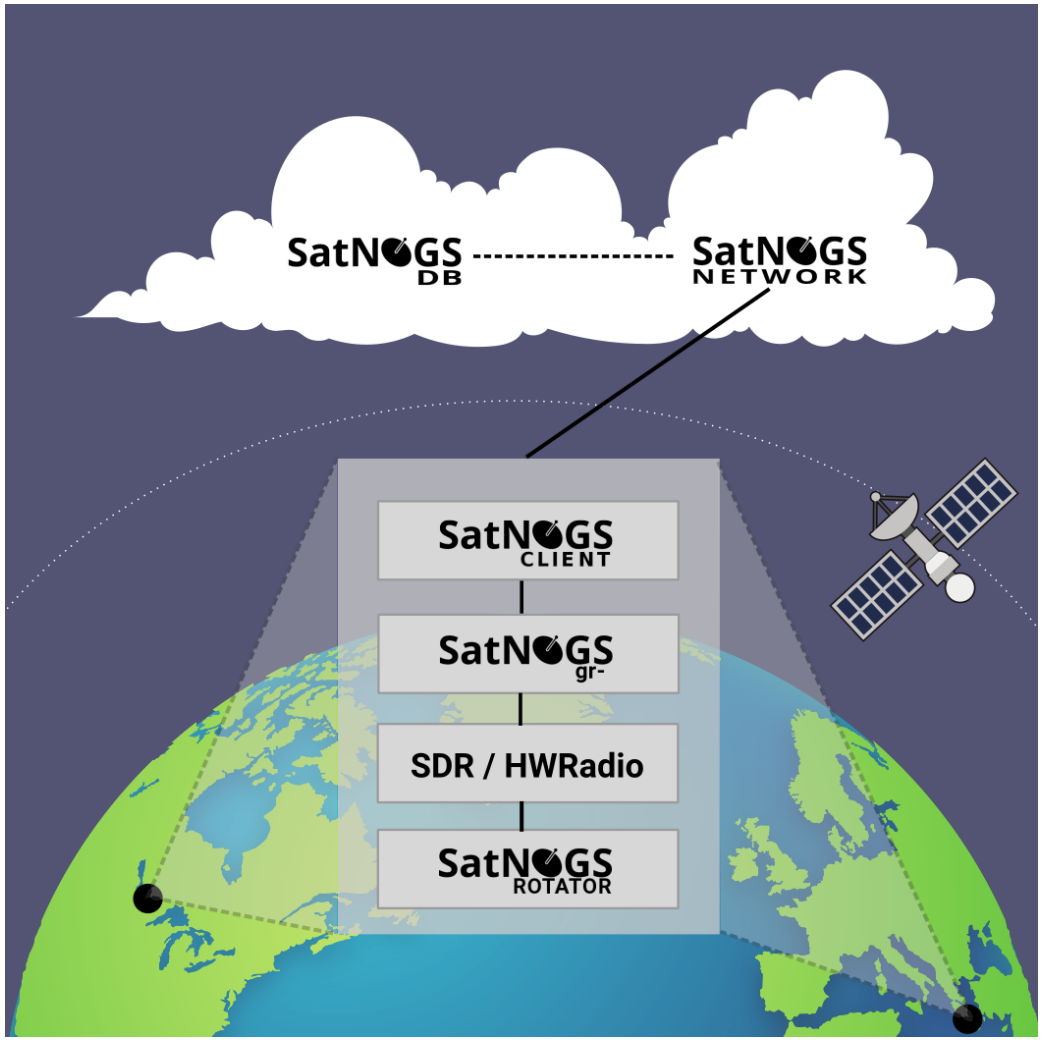
SatNOGS: An SDR-based Satellite Networked Open Ground Station

Libre Space Foundation

Manolis Surligas

February 4, 2017

SatNOGS in a nutshell



SatNOGS: Satellite Networked Open Ground Station

SatNOGS

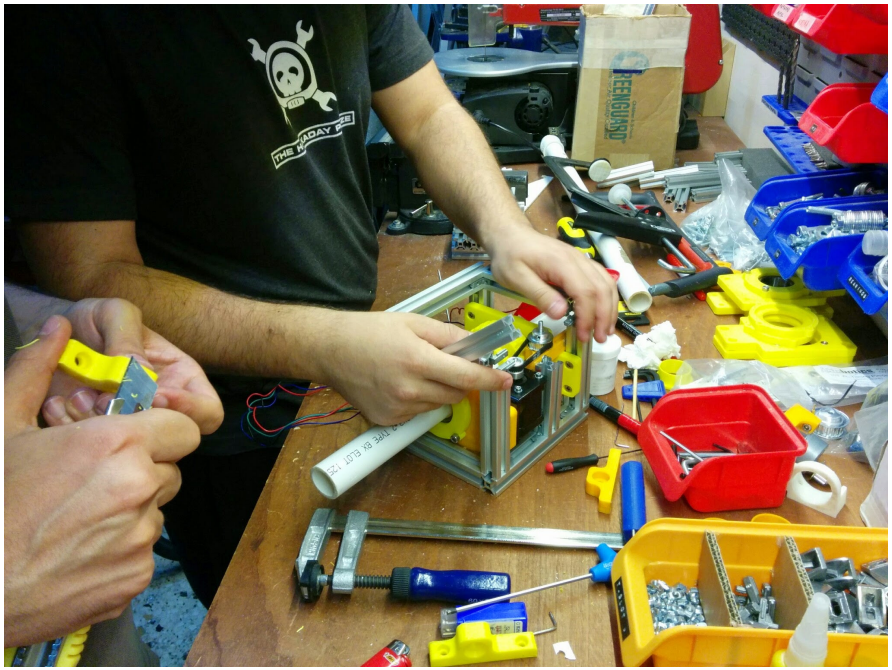
SatNOGS in a nutshell

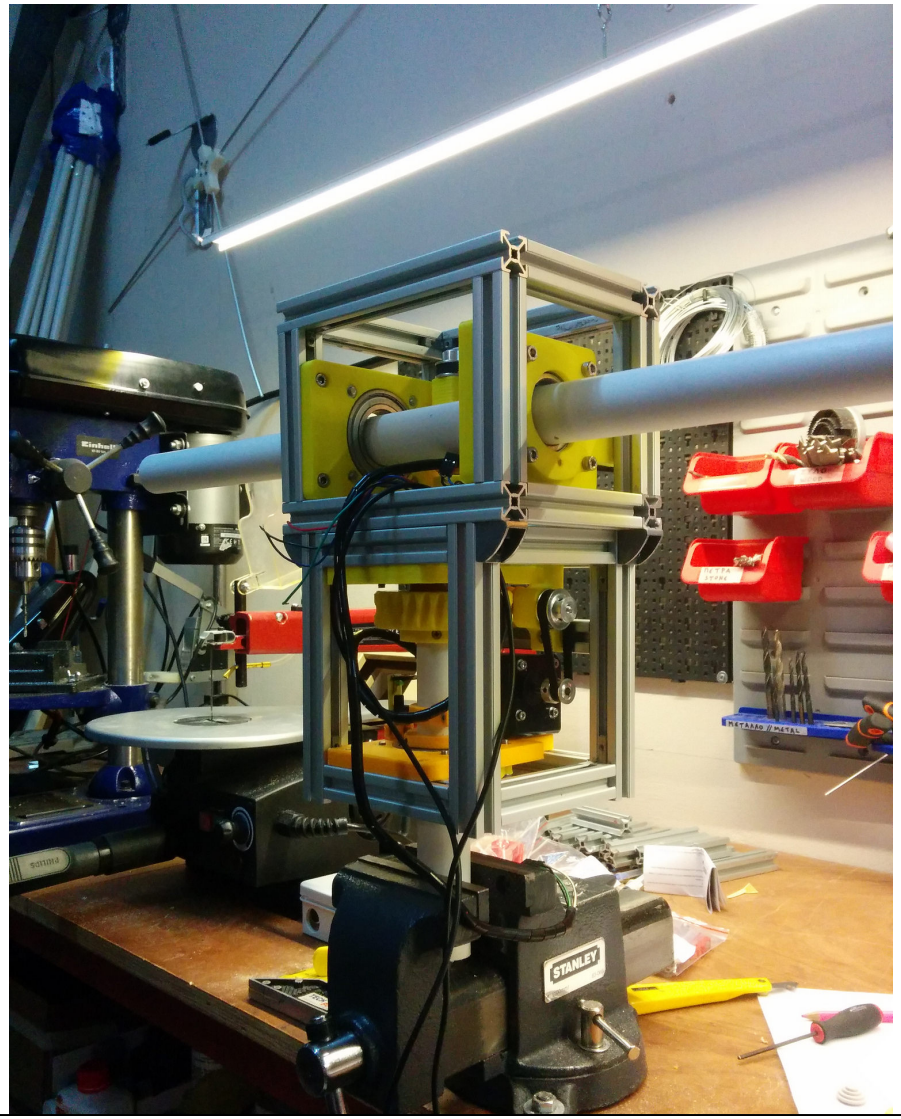
- Global network of ground stations
- Focus on receiving LEO satellite signals
- Open software **and** hardware
- Costs about 300 to 500 $
- SDR enabled RF front-end for maximum flexibility

SatNOGS in a nutshell

- LEO satellites can be observed only for few minutes per location
- A global network of ground stations can increase the observation time
- Data from the deployed ground stations are uploaded on the cloud for easy access
- Web Support for observations scheduling on ground stations with LOS with the target

SatNOGS Rotator





SatNOGS Rotator

The gr-satnogs GNU Radio module

- SatNOGS ships together with the *gr-satnogs* GNU Radio module
- Code available at `https://github.com/satnogs/gr-satnogs`
- Supports multiple SDR devices through the *gr-osmocom* module
- Responsible for capturing filtering and demodulating satellite signals

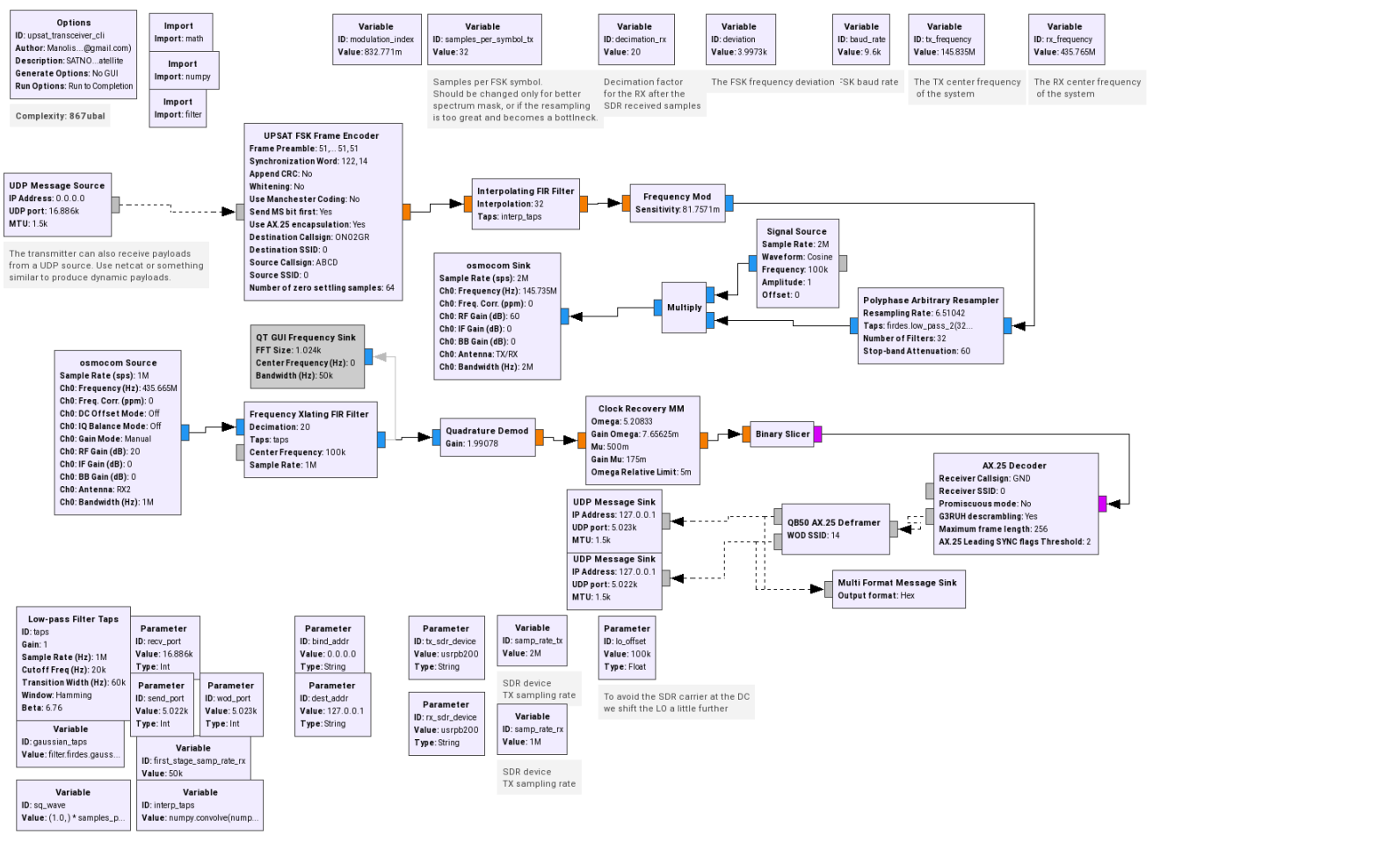
The gr-satnogs GNU Radio module

- **Can operate stand-alone**
- Can be used also for satellite development, experimentation and debugging
  - UPSat success story :)
  - LibreSat-i follows!
- Runs on Linux (x86, ARM)
- Raspberry Pi 3 full support

gr-satnogs and UPSat

SatNOGS

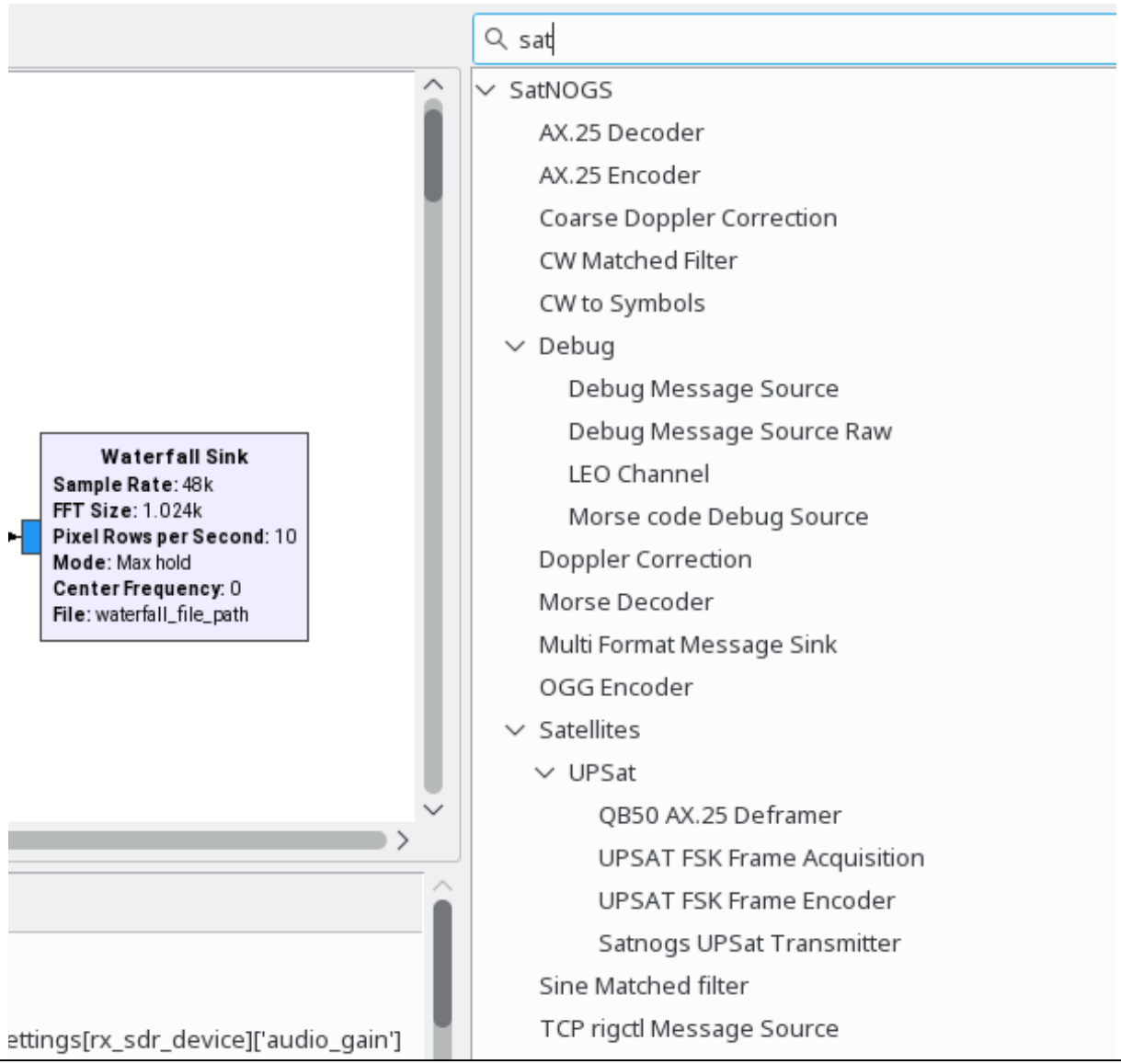
gr-satnogs and UPSat



UPSat transceiver flowgraph!

SatNOGS

The gr-satnogs GNU Radio module



SatNOGS

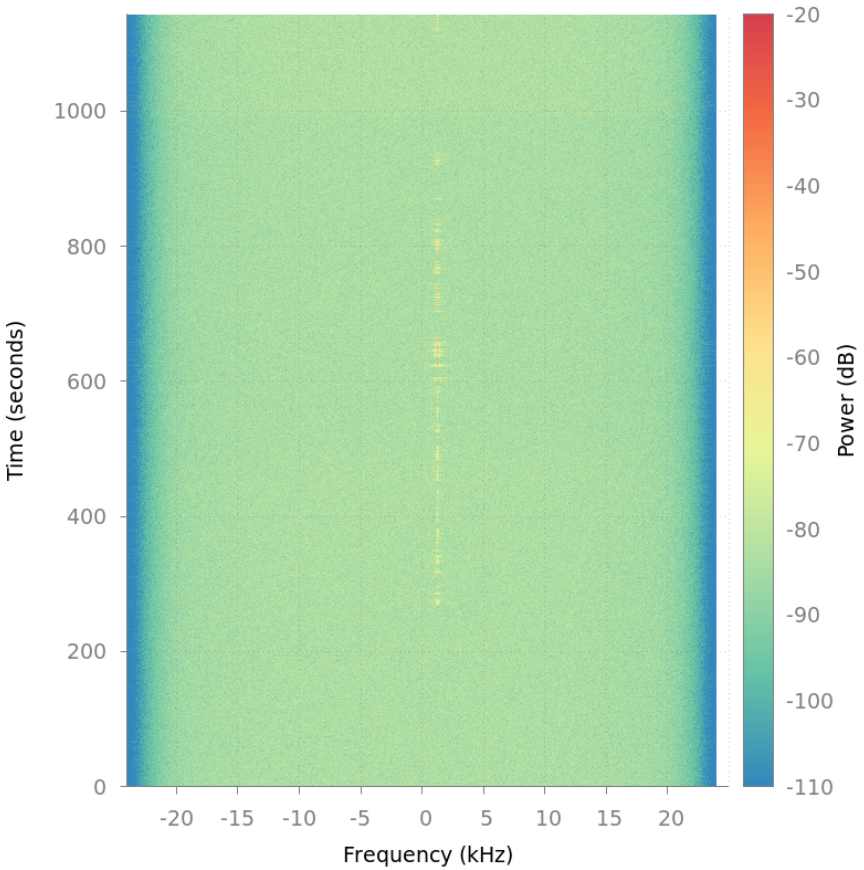
Doppler effect correction

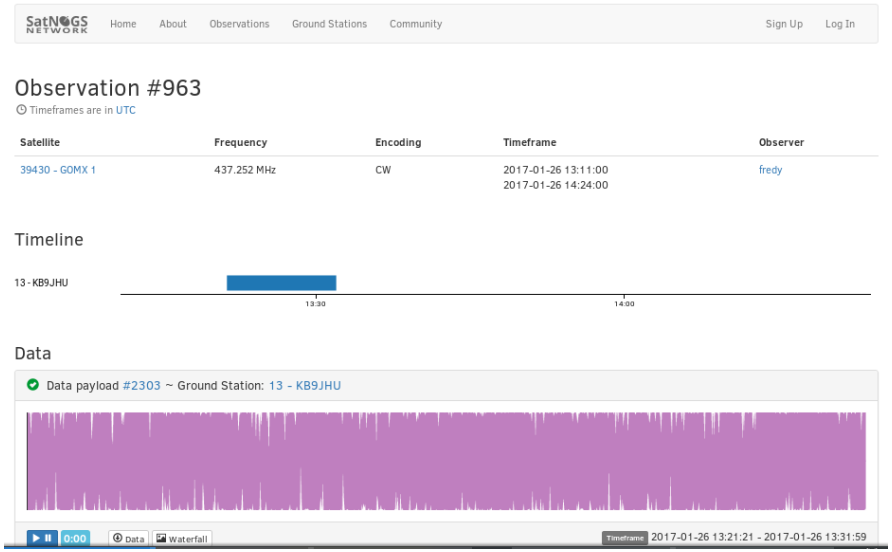
- LEO communication channel suffers from large frequency offsets due to the Doppler effect
- The frequency offset changes constantly during the observation period
- Based on the satellite telemetry and transponder frequency, we compute the speed of the satellite and the frequency offset
- *gr-satnogs* incorporates two Doppler correction blocks:
  - **Coarse:** ~10 corrections per second based on the trajectory → less CPU
  - **Fine:** ~1000+ corrections per second based on both trajectory and curve fitting → more CPU

Web integration

- *gr-satnogs* can operate with *satnogs-client* to upload satellite information on cloud
- The information that is uploaded includes:
  - An audible representation of the received signal in .ogg format
  - A waterfall plot image of the whole observation
  - Demodulated bit-stream if enough framing information about the satellite is available

Web integration





SatNOGS

Automated Signal Detection

- Many of the satellite observations contain no data
- This can happen for many reasons:
  - Satellites often shutdown transceivers for energy saving
  - Or they shutdown their transponders during night
  - Outdated TLE
- *gr-satnogs* incorporates an automatic system to distinguish observations with signal presence

Latest Observations | Scheduled Observations

ID	Satellite	Frequency	Encoding	Timeframe	Observer
968	TIANWANG 1B (TW-1B)	437.645 MHz	GMSK4k8	2017-01-28 14:45:00 2017-01-28 14:56:00	Corey Shields
967	CUTE-1.7+APD II (CO-65)	437.275 MHz	CW	2017-01-28 12:18:00 2017-01-28 12:31:00	Nikos Roussos
966	BY70-1	436.200 MHz	BPSK	2017-01-27 03:06:00	Corey Shields

SatNOGS

Next Steps - Early Work

- **MIMO SDR Receiver**
- **Add more satellites!**

MIMO SDR beam-forming for LEO satellites

- 2x2 Phased array can potentially replace SatNOGS rotator
- Quad Helix Antenna Elements pose an attractive option for the array
- MIMO beam-steering allows for concurrent reception of multiple satellites
- No moving parts

Join the hunt!

www.satnogs.org