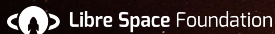


# Claim Space, the Libre Way

GNU Radio Conference 2018

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Manolis Surligas  
Libre Space Foundation



# Introduction

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- A non profit organization based in Athens, Greece
- Focus on space applications
- Commitment to open technologies
- Educational activities

- Established in 2014 after winning the Hackaday prize
- The winning project was the core of the **SatNOGS**

# SatNOGS

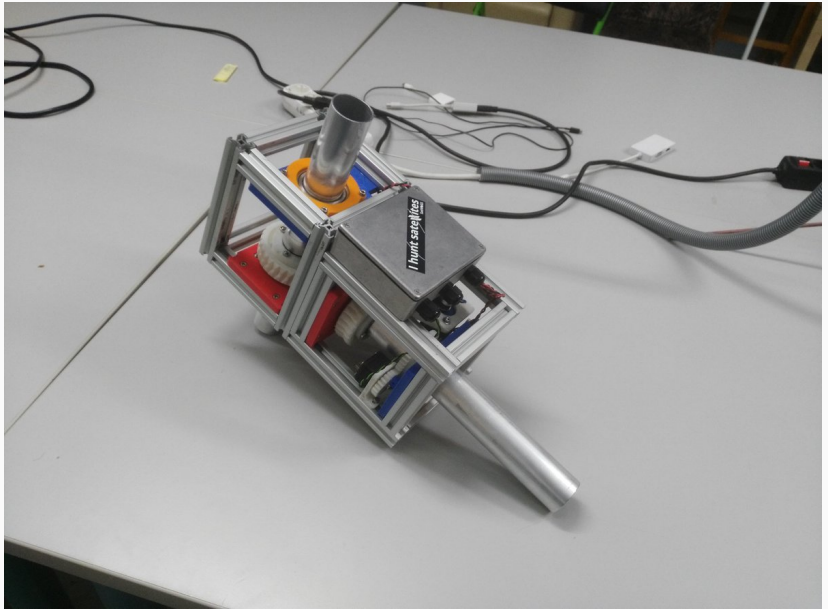
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# SatNOGS in a nutshell



- Global network of ground stations
- Focus on receiving LEO satellite signals
- Open Software **and** Open Hardware
- Typical station costs about 400 USD
- SDR enabled RF front-end for maximum flexibility

# SatNOGS Rotator



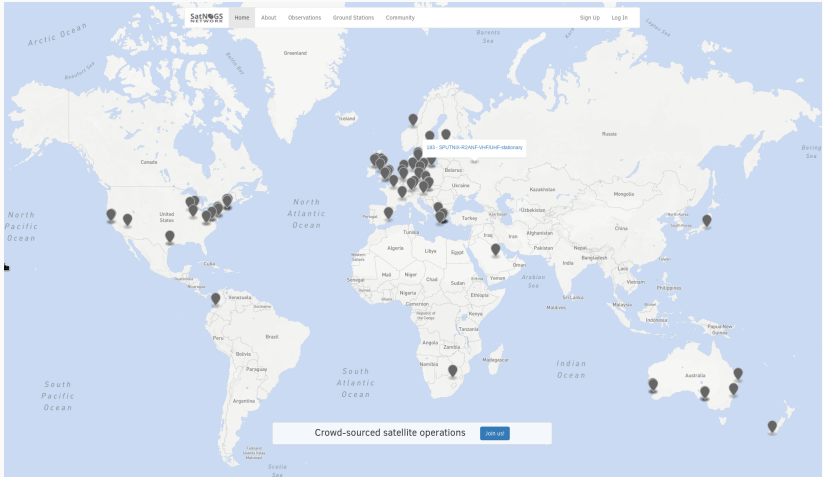


# SatNOGS Rotator



# SatNOGS Network

- 60 stations online
- 40 under testing



- Over **1000** observations per day

## Observations

« 1 2 3 4 ... 9470 »



**Status**

**Results**

**Satellite** All

**Observer** All

**Station** All

**Start Time**

**End Time**

[Update filters](#)

ID	Satellite	Frequency	Encoding	Timeframe	Results	Observer	Station
251749	ELFIN-B	437.475 MHz	FSK19k2	2018-09-16 16:45:50 2018-09-16 16:55:32		sp2zie	254 - SP2ZIE - 70cm
251490	CP 7 (DAVE)	437.150 MHz	FSK9k6	2018-09-16 16:45:21 2018-09-16 16:55:59		Patrick Dohmen	49 - OZ7SAT
251578	SurfSat	437.275 MHz	FSK9k6	2018-09-16 16:45:06 2018-09-16 16:56:27		Dimitrios Papadeas	31 - GI7UGV - UHF
251705	CP 7 (DAVE)	437.150 MHz	FSK9k6	2018-09-16 16:44:34 2018-09-16 16:55:43		Cees Bassa	40 - CGBSAT-UHF
251476	CP 7 (DAVE)	437.150 MHz	FSK9k6	2018-09-16 16:43:46 2018-09-16 16:54:55		Patrick Dohmen	37 - DL4PD
251005	XW-2A	145.660 MHz	CW	2018-09-16 16:43:14 2018-09-16 16:54:11		Dimitrios Papadeas	183 - SPUTNIX-R2ANF-VHF/UHF-stationary
251529	CP 7 (DAVE)	437.150 MHz	FSK9k6	2018-09-16 16:43:09 2018-09-16 16:53:59		Alex DD1ALX	47 - DB0RV
251674	S-NET C	2263.000 MHz	FM	2018-09-16 16:42:41		Dimitrios Papadeas	2 - KB9JHU

## Observation #251820

[Discuss](#)

Timeframes are in UTC

**Satellite** 43017 - FOX-1B  
**Station** 223 - W2MMD GCARC Clubhouse Jon Pearce  
**Observer**  
**Status** Good  
**Transmitter** TLM  
**Frequency** 145.960 MHz  
**Encoding** DUV  
**Timeframe** 2018-09-16 16:08:59  
2018-09-16 16:19:53

**Rise** ● 124.0°  
**Max** 15.0°  
**Set** ● 5.0°  
**Client Version** 0.7

**Metadata** [▶ { 4 items }](#)

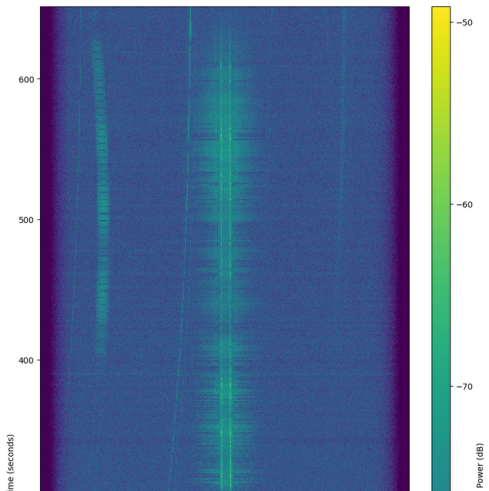
**Polar Plot**



**Downloads**

[Audio](#) [Waterfall](#)

[Waterfall](#) [Audio](#) [Data](#) 23



## Observation #251820

[Discuss](#)

⊙ Timeframes are in UTC

**Satellite** 43017 - FOX-1B

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**Status** Good

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2018-09-16 16:08:59  
2018-09-16 16:19:53

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**Max** 15.0°

**Set** ● 5.0°

**Client Version** 0.7

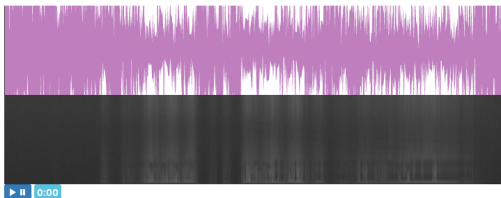
**Metadata**

**Polar Plot**



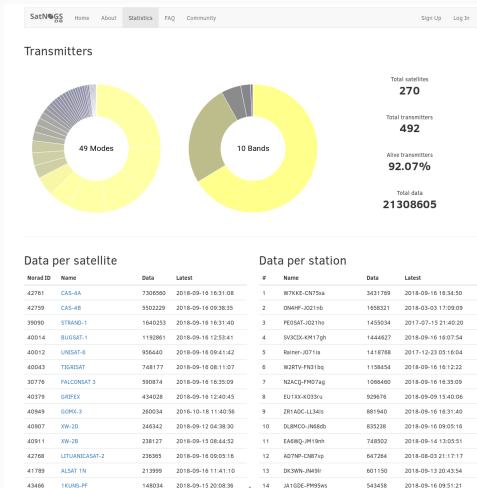
**Downloads** [Audio](#) [Waterfall](#)

[Waterfall](#) [Audio](#) [Data](#) 23

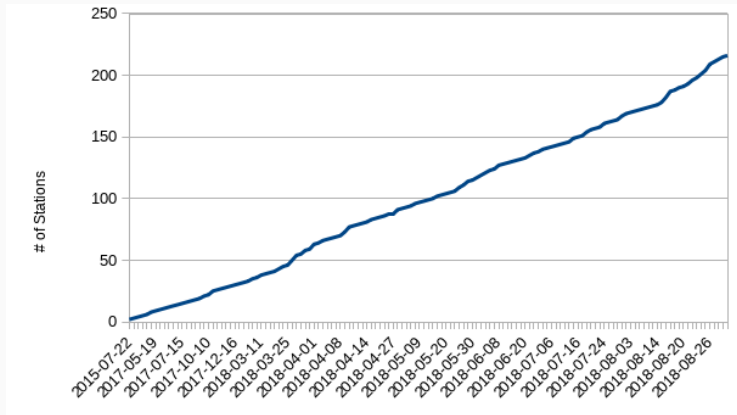




- 270 satellites
- 492 different transmitters
- Over 21M frames decoded

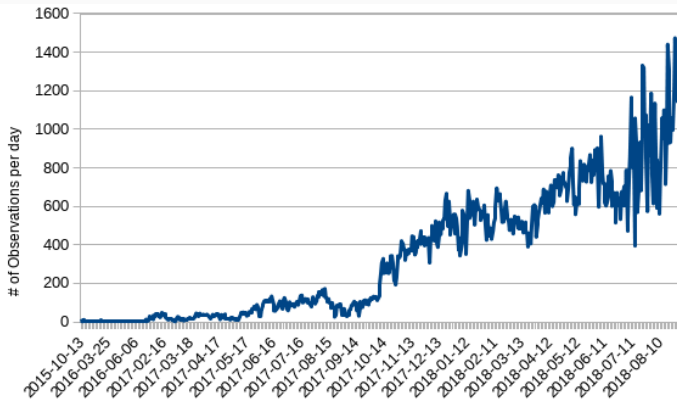


## Registered Stations

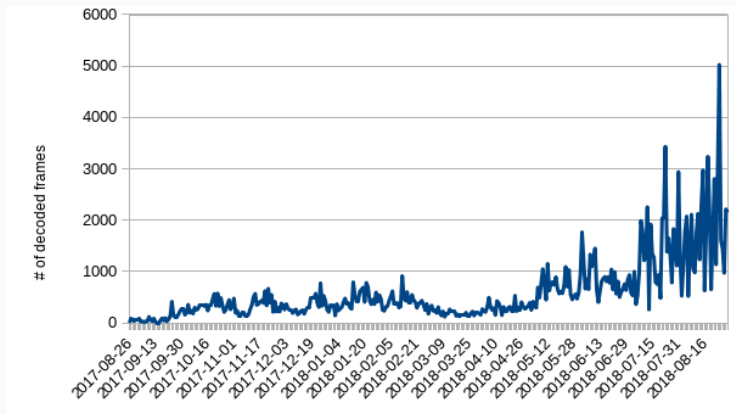




## Observations per day



## Decoded frames per day



- *gr-satnogs* is the GNU Radio OOT module of SatNOGS
- Supports most of the SDR devices
- Compensates the Doppler shift
- Support for custom RF parameters (gain, device arguments, sampling rate)
- Flowgraphs for automatic decoding

*gr-satnogs* currently supports decoders for:

- CW
- APRS1200 and APRS9600
- AX.25 FSK(1200-19200)
- AX.25 MSK(1200-19200)
- AX.25 AFSK(1200-9600)
- APT
- DUV
- BPSK1200

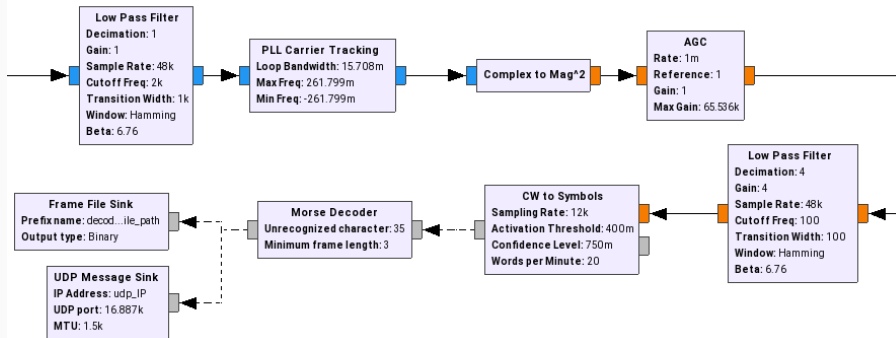
Flowgraphs of the decoders can be retrieved from the [apps](#) directory of the *gr-satnogs* OOT GNU Radio module

# CW (Continuous wave, Morse Code)

- Extremely popular in Cubesat missions
- We developed an PLL-assisted amplitude based decoder

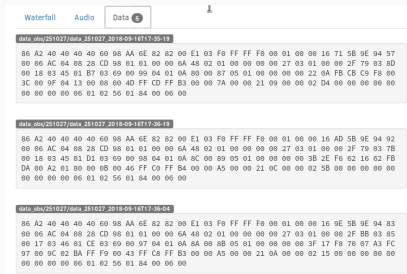
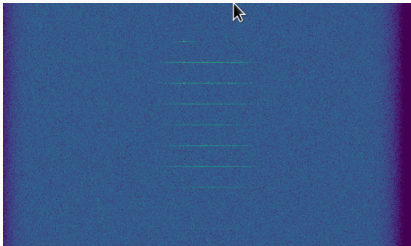
UPSat 12:32 UTC CW Beacon

U P S A T T K M D V Z F



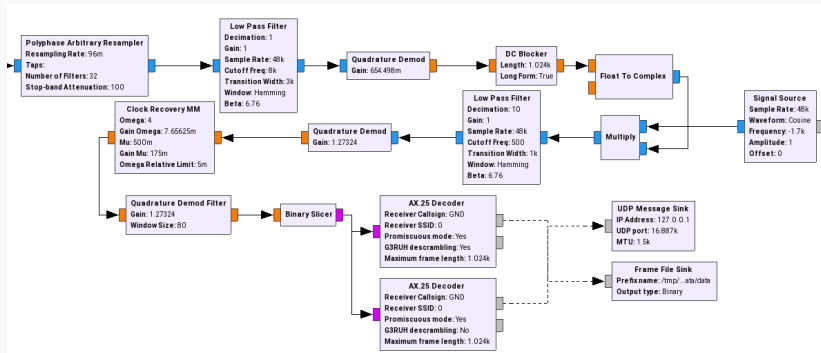
# AX.25 FSK

- Very popular in hamradio and Cubesats
- G3RUH self synchronizing scrambler for baudrates  $> 1200$
- CRC32 for integrity check



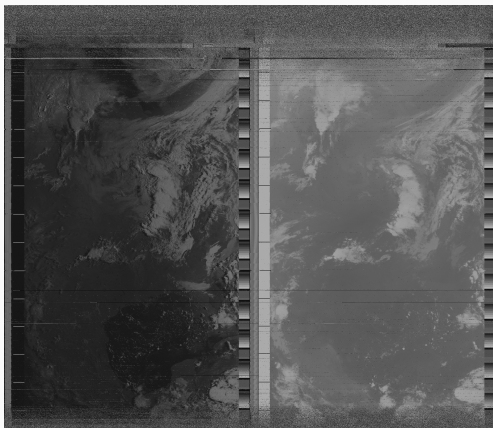
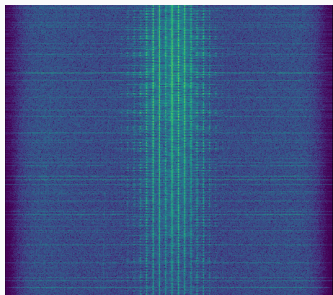
# AX.25 AFSK 1200

- Audible FSK over an FM carrier
- Very popular in LEO missions
- Two quadrature demodulators for the decoding



# APT (Automatic Picture Transmission)

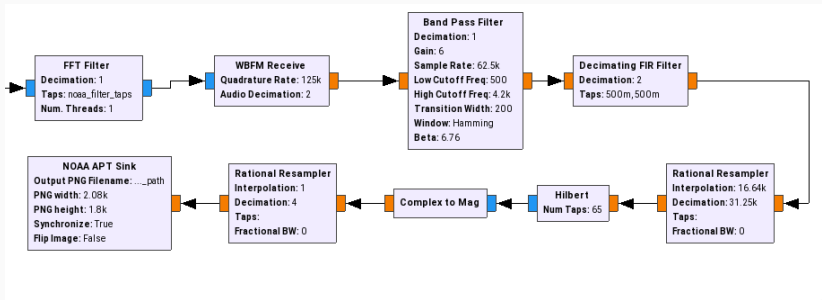
- Analog image transmission
- Used by NOAA weather satellites
- AM over FM @ 34 kHz bandwidth
- 5 Watts on 137 MHz





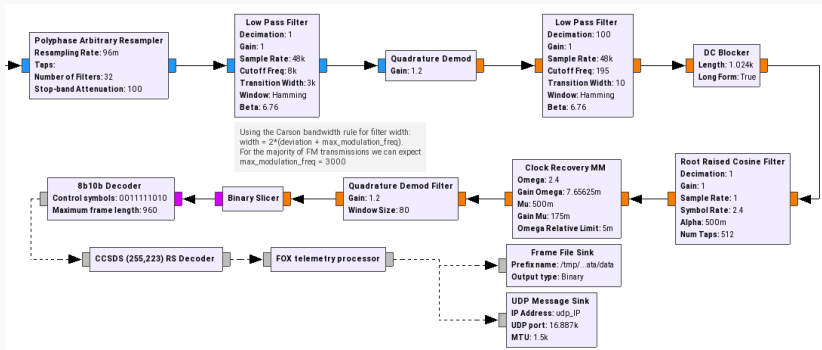
# APT (Automatic Picture Transmission)

- Analog image transmission
- Used by NOAA weather satellites
- AM over FM @ 34 kHz bandwidth
- 5 Watts on 137 MHz



# DUV (Data Under Voice)

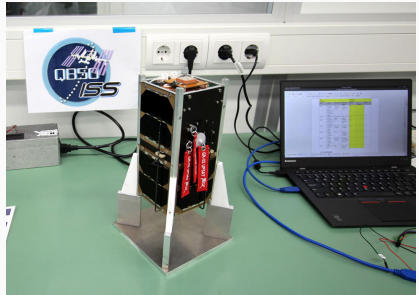
- Used in AMSAT FOX satellites
- Low speed telemetry under FM voice transmissions
- 8b10b encoding and RS

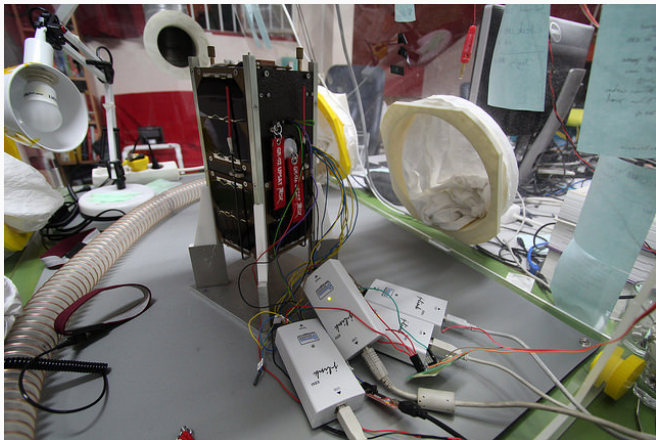


**UPSat**

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- First open-source hardware/software cubesat
- Part of the QB50 project
- Developed by the Libre Space Foundation and the University of Patras

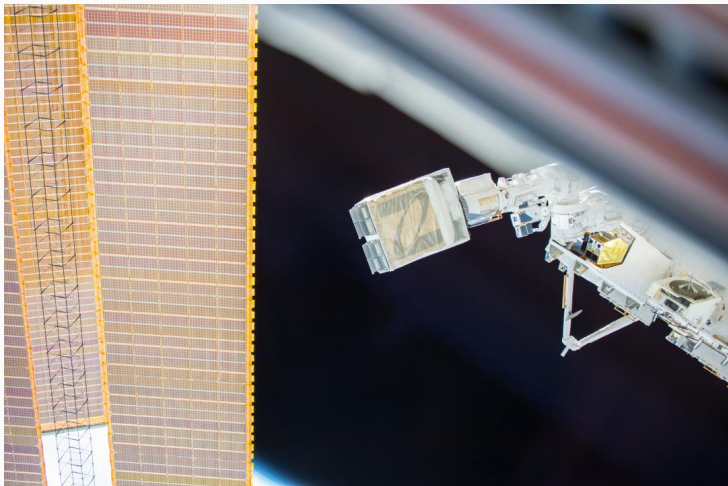




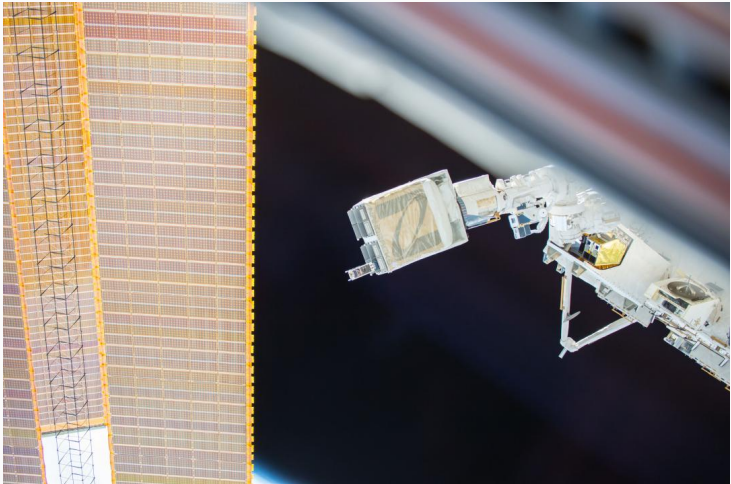


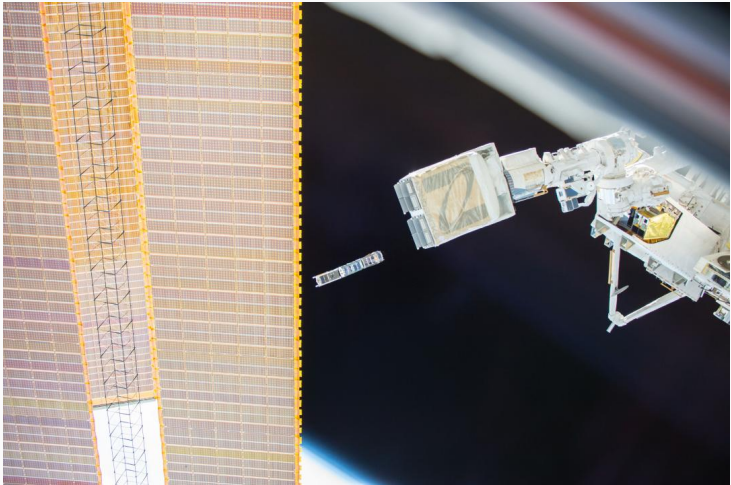


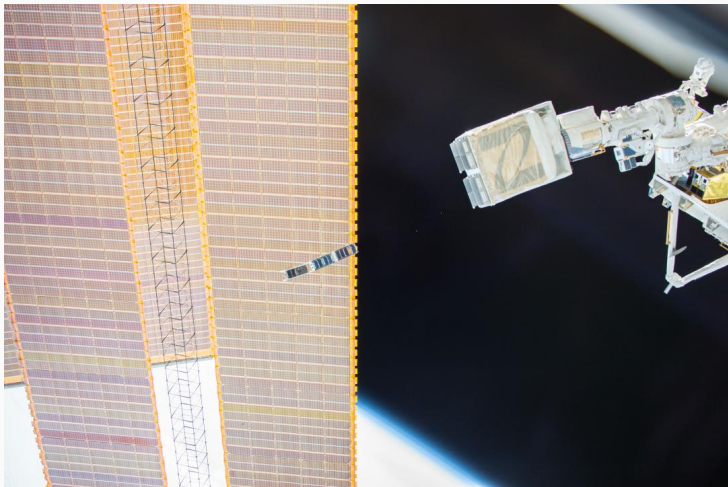
- Launched on 18<sup>th</sup> April 2017 on an Atlas V rocket

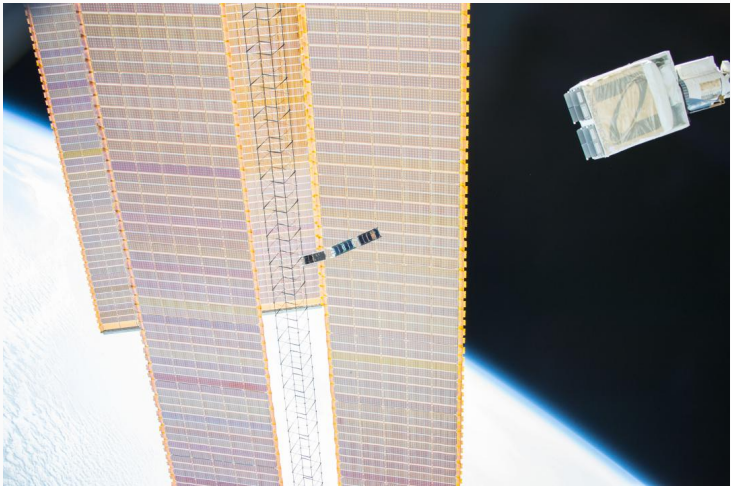


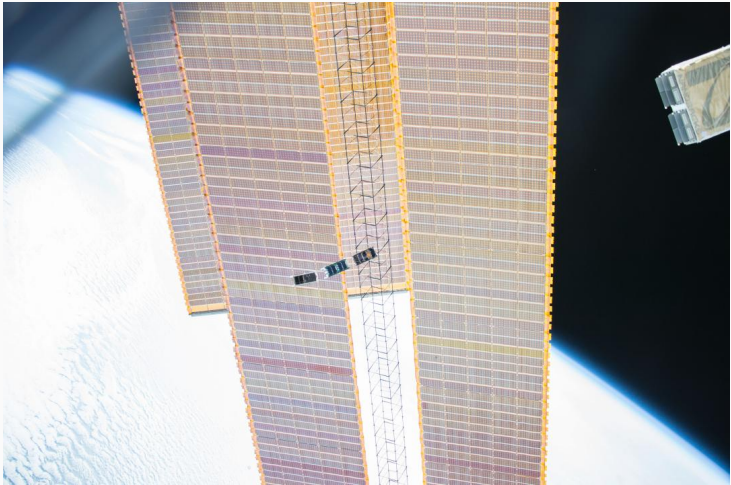


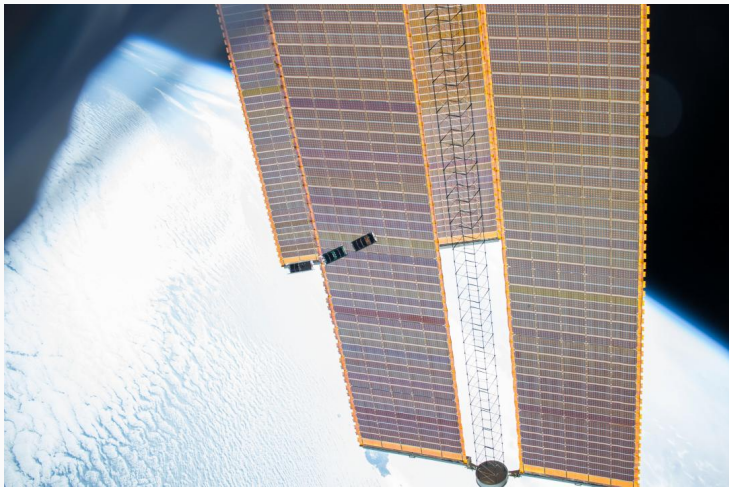


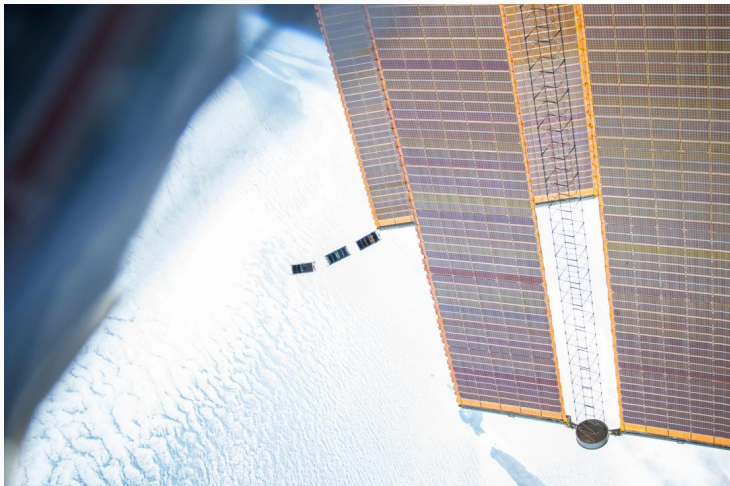


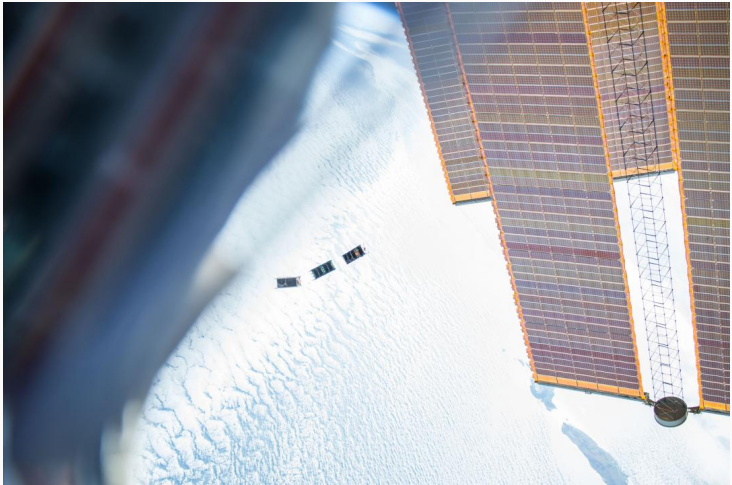






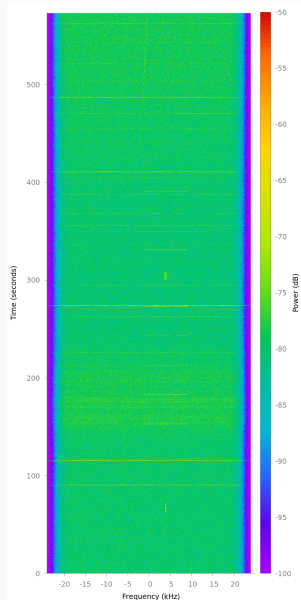








- First transmissions received just 30 minutes after deployment by a SatNOGS ground station in the USA
- CW and FSK9600 frames decoded using gr-satnogs decoders



# ESA SDR Makerspace

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- An ESA - LSF collaboration
- 14-month program with a budget of 500k euros
- Investigate the use of SDR technology in space applications
- Umbrella activity for 15+ subactivities around SDR and space communication
- Several subactivities include contributions to GNU Radio
- All results released as open source software and hardware



- Use Soapy API to interface with SDR hardware
- Extract device capabilities dynamically
- Deprecates the gr-osmosdr
- <https://gitlab.com/librespacefoundation/gr-soapy.git>



- A model emulating the LEO channel
- Path loss based on distance and/or atmospheric absorption
- Doppler effect
- Great tool for prototyping and experimentation
- <https://gitlab.com/librespacefoundation/gr-leo.git>

## More to come

- SDR hardware radiation testing
- Contributions to DVB-S2
- CCSDS Decoders
- New SDR software platforms
- Framework for SDR testing CI/CD
- More info at <https://sdrmaker.space>





**Thank you!**