The use of gr-satellites to receive the Kenyan satellite 1KUNS-PF

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About the speaker

- PhD in Mathematics
- Day job: in GMV (Madrid) as a GNSS engineer, developing GNSS receivers and simulators
- Independent researcher in radio communications, radio science, space systems and other topics
- Amateur radio operator (EA4GPZ, M0HXM)
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Amateur radio

- ITU defines it as
  A radiocommunication service for the purpose of self-training, intercommunication and technical investigations carried out by amateurs, that is, by duly authorized persons interested in radio technique solely with a personal aim and without pecuniary interest.
- Essentially, it is radio spectrum for citizens
- A huge world wide community of people interested in radio, willing to help and perform experiments

Amateur satellites

- Amateur-satellite service, defined by ITU as
  A radiocommunication service using space stations on earth satellites for the same purposes as those of the amateur service.
- Several hundreds of Amateur satellites have been flown in history:
  - Satellites built by Amateur radio operators, mainly for communications
  - Some satellites built by universities and research institutions, for education or research
  - Unfortunately, also some technology demonstrators built by private companies
- Lately, the number of private companies using the Amateur satellite service as a means to get "free spectrum" is increasing. This goes against ITU regulations, but currently no one is stopping it.
- There are already movements within the Amateur community to try to stop this. What we lack mainly is "executive power".

gr-satellites

- A GNU Radio out-of-tree module with a collection of telemetry decoders for Amateur satellites
- GNU Radio: a free & open-source software development toolkit that provides signal processing blocks to implement software radios
- Out-of-tree module: some kind of library or plugin for GNU Radio
- I started the gr-satellites project in 2015 with the goal of making it possible to decode every Amateur satellite in orbit
- Currently around 80 different satellites supported
- Open-source: GPLv3
- https://github.com/daniestevez/gr-satellites

1KUNS-PF

- 1st Kenyan University Nano Satellite - Precursor Flight
- First (and only) Kenyan satellite, launched to the ISS in April 2018 with a competitive grant from UNOOSA (joint project between UN and JAXA)
- Released in orbit on 11 May 2018 from the Japanese experiment module Kibo
- Joint engineering project between Nairobi University and University of Rome "La Sapienza"
- Has an on-board camera and uses the Amateur radio satellite service
- 1U cubesat format (10x10x10cm cube, approx. 1kg of mass)
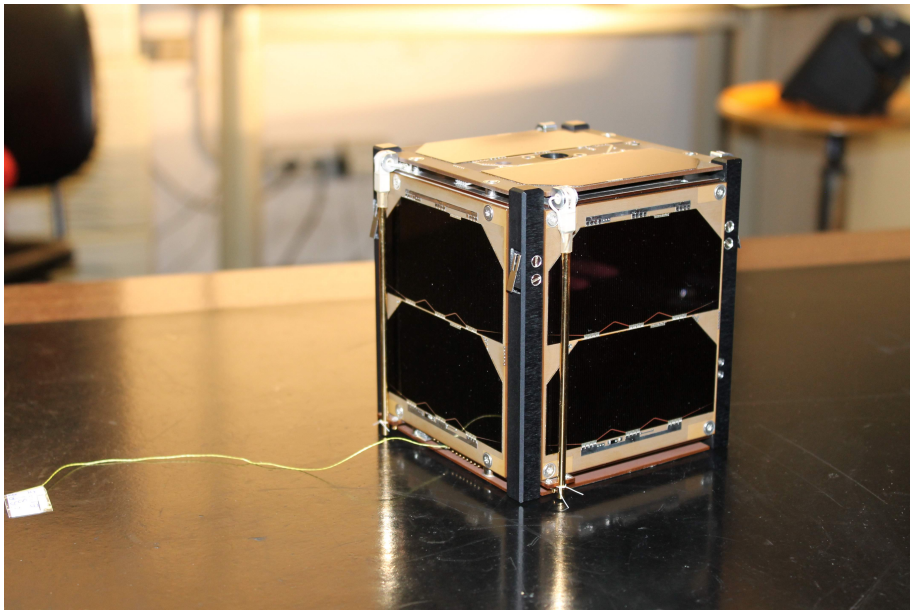
- The 1KUNS-PF team didn't publish any technical information about the radio transmissions of the satellite
- Mike Rupprecht DK3WN, in Germany, and I looked at the signals of the satellite shortly after it was put in orbit
- I tried to do some reverse-enginnering, with partial success
- Mike managed to get in contact with the people at Rome La Sapienza, who gave us the technical data we were missing. I added a 1KUNS-PF decoder to gr-satellites.
- Mike discovered some JPEG images in the data. I added an image decoder to gr-satellites.

- Other Amateur operators that have collaborated: Scott Chapman K4KDR, and Rocco Valenzano W2RTV (USA), who gathered data and tested the decoders. Andrei Kopanchuk UZ7HO (Ukraine), who made another decoder.
- SatNOGS network: a worldwide distributed network of groundstations made by Amateur radio operators and other interested persons. More than 4000 observations for 1KUNS-PF
- SatNOGS Database: stores data frames that people in the network have received. More than 2 million frames for 1KUNS-PF
- All this data gathered by Amateurs can be accesed by the 1KUNS-PF team. Having a worldwide groundstation network represents a huge asset.
- In August 2019, Alexandru Csete OZ9AEC and Sheila Christiansen (Denmark) have been in Kenya talking with the 1KUNS-PF team and installing a SatNOGS groundstation

Conclusions

- The 1KUNS-PF mission shows how the Amateur radio community is an excellent example of worldwide collaboration
- Amateur operators collaborate without economical interests, mainly for learning, experimentation and fun
- Radio waves do not know about country borders. International contacts are common in Amateur radio, so international collaboration is very natural
- 1KUNS-PF is just one example of many. We give the same degree of attention to other satellites.

Demo of 1KUNS-PF real-time image and telemetry decoder