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Enter the Electromagic Spectrum with the USRP

GNU Radio Conference 2018

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$ universe --help

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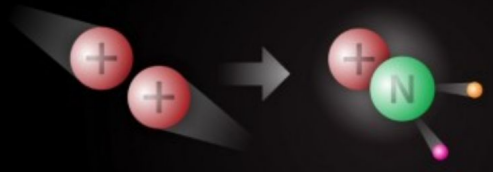
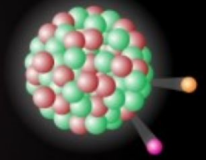
Weak Nuclear Force



Converting protons into neutrons

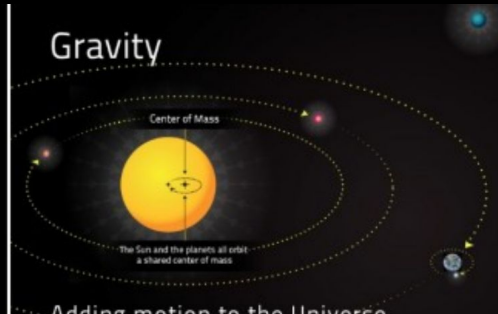
When two protons collide and fuse, a disruption in the weak nuclear force emits a positron and neutrino, which converts one of the positively charged proton to a neutrally charged Nuetron. Without the weak nuclear force converting protons into nuetrons, certain complex nuclei cannot form.



Releasing radiation

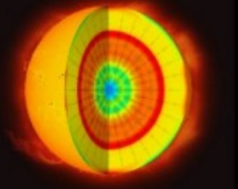
Heavy atoms have an imbalance of protons and nuetrons, so the weak nuclear force converts protons to nuetrons releasing radiation.

Gravity



Adding motion to the Universe

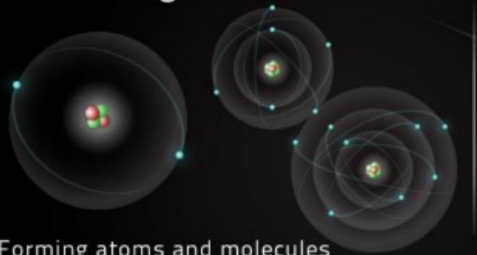
Gravity forms stars, planets, and moons, and forces these objects to spin on an axis and move along an orbital path. The planets appear to be orbiting the center of the Sun, but the Sun and planets all orbit a shared center of mass. Planets with enough mass can develop orbiting moons or rings of debris.



Creating energy

Gravity is the force that creates pressure and fusion energy in the core of stars allowing them to burn for millions of years.

Electromagnetic Force



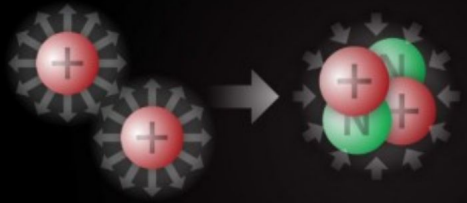
Forming atoms and molecules

The electromagnetic force pulls negatively charged electrons into bound orbits around positively charged nuclei to form atoms and molecules. As a gas cools, electrons will find their way into the presence of atomic nuclei. Larger nuclei with a greater positve charge pull in more electrons until atoms and molecules have a balance of charges.

Generating light

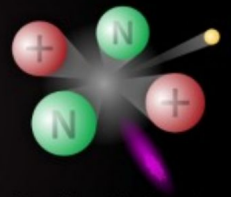
When a negative electron interacts with a positive proton, the electromagnetic force adds energy to the electron generating a photon.

Strong Nuclear Force



Binding protons in atomic nuclei

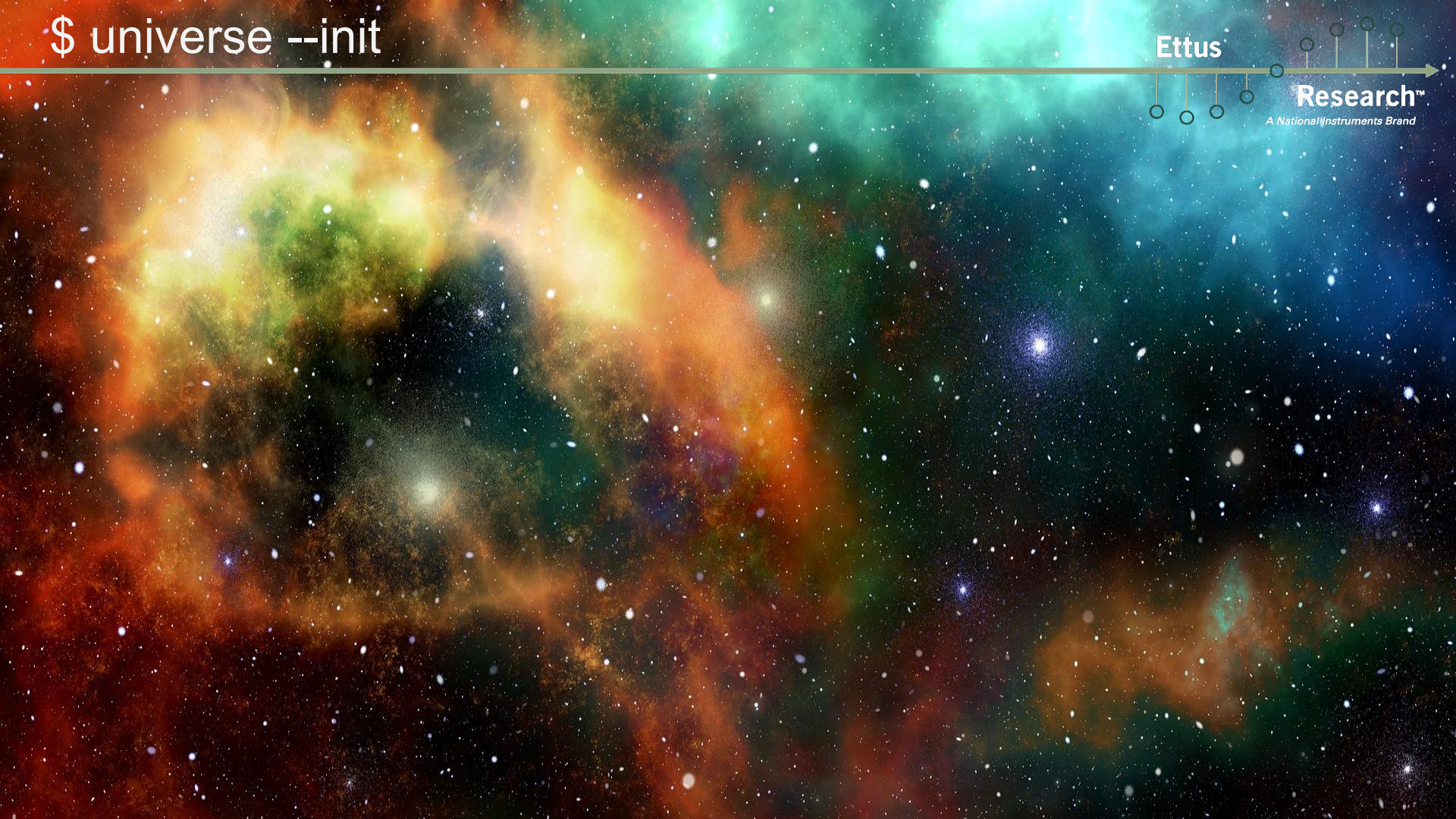
Positively charged particles naturally repel each other, it takes an extreme amount of force to hold protons together. The strong nuclear force overcomes the repulsion between protons to hold together atomic nuclei. Without the strong nuclear force, complex nuclei cannot form.



Breaking the bond

Enormous energy is released as gamma rays and nuetrinos when the strong nuclear force is broken between protons and neutrons.

$ universe --init



$ universe --display earth

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$ universe --display earth

$ universe --display earth

$ universe --display earth

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$ universe --display earth

$ universe --display earth

$ universe --display earth

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$ universe --display modern-world

Ettus Research™
A National Instruments Brand

$ universe --display old-world

Ettus Research™
A National Instruments Brand

$ universe --display modern-world

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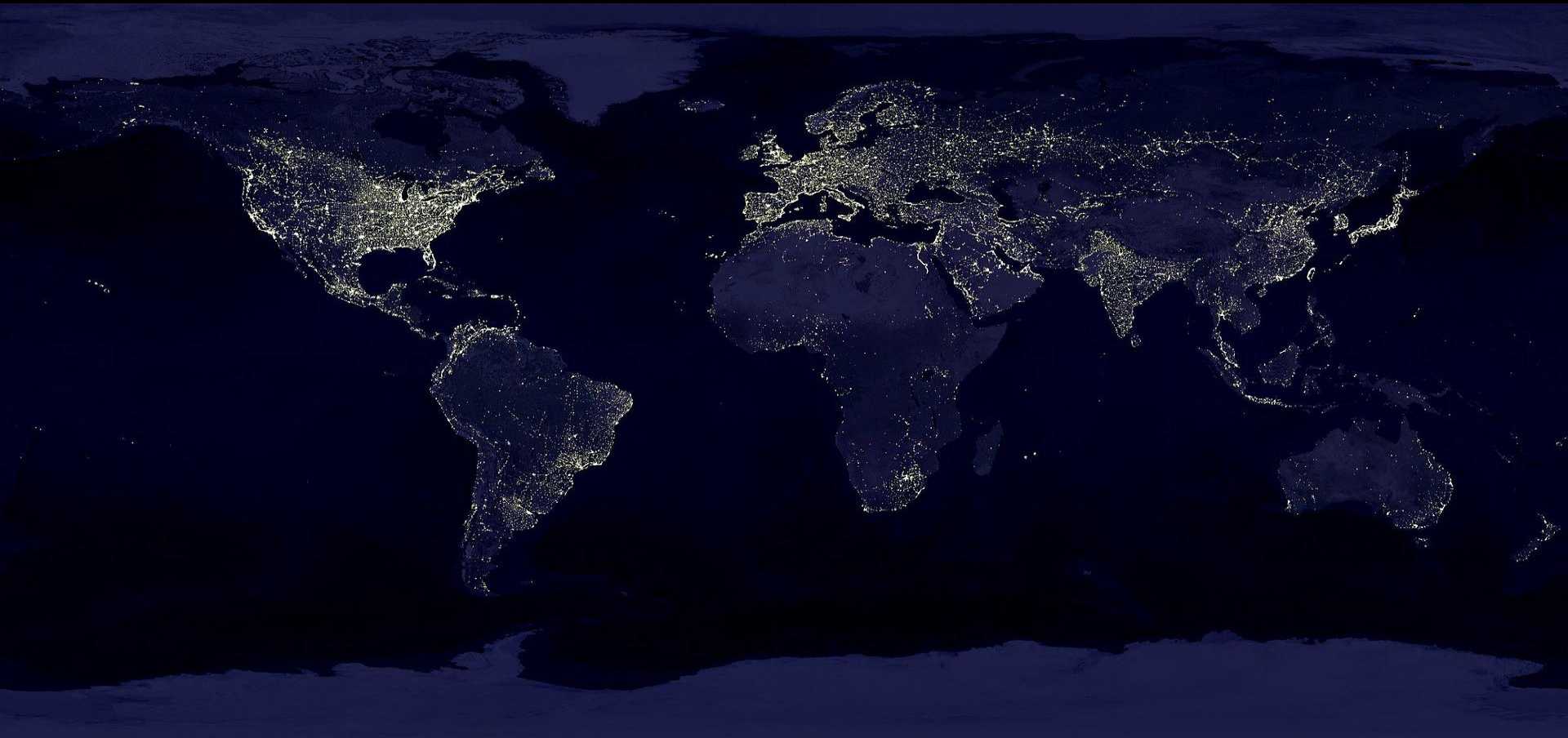

$ universe --interface wlan0

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$ universe --print-rules

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$$\int_S \mathbf{E} \cdot d\mathbf{a} = \frac{1}{\epsilon_0} \int \rho \, dV$$

$$\int_S \mathbf{B} \cdot d\mathbf{a} = 0$$

$$\int_{\text{loop}} \mathbf{E} \cdot d\mathbf{s} = -\frac{d}{dt} \int_S \mathbf{B} \cdot d\mathbf{a}$$

$$\int_{\text{loop}} \mathbf{B} \cdot d\mathbf{s} = \mu_0 \int_S \mathbf{J} \cdot d\mathbf{a} + \epsilon_0 \mu_0 \frac{d}{dt} \int_S \mathbf{E} \cdot d\mathbf{a}$$

$ universe --flush-rules

What if...

$ pybombs install gr-gravity

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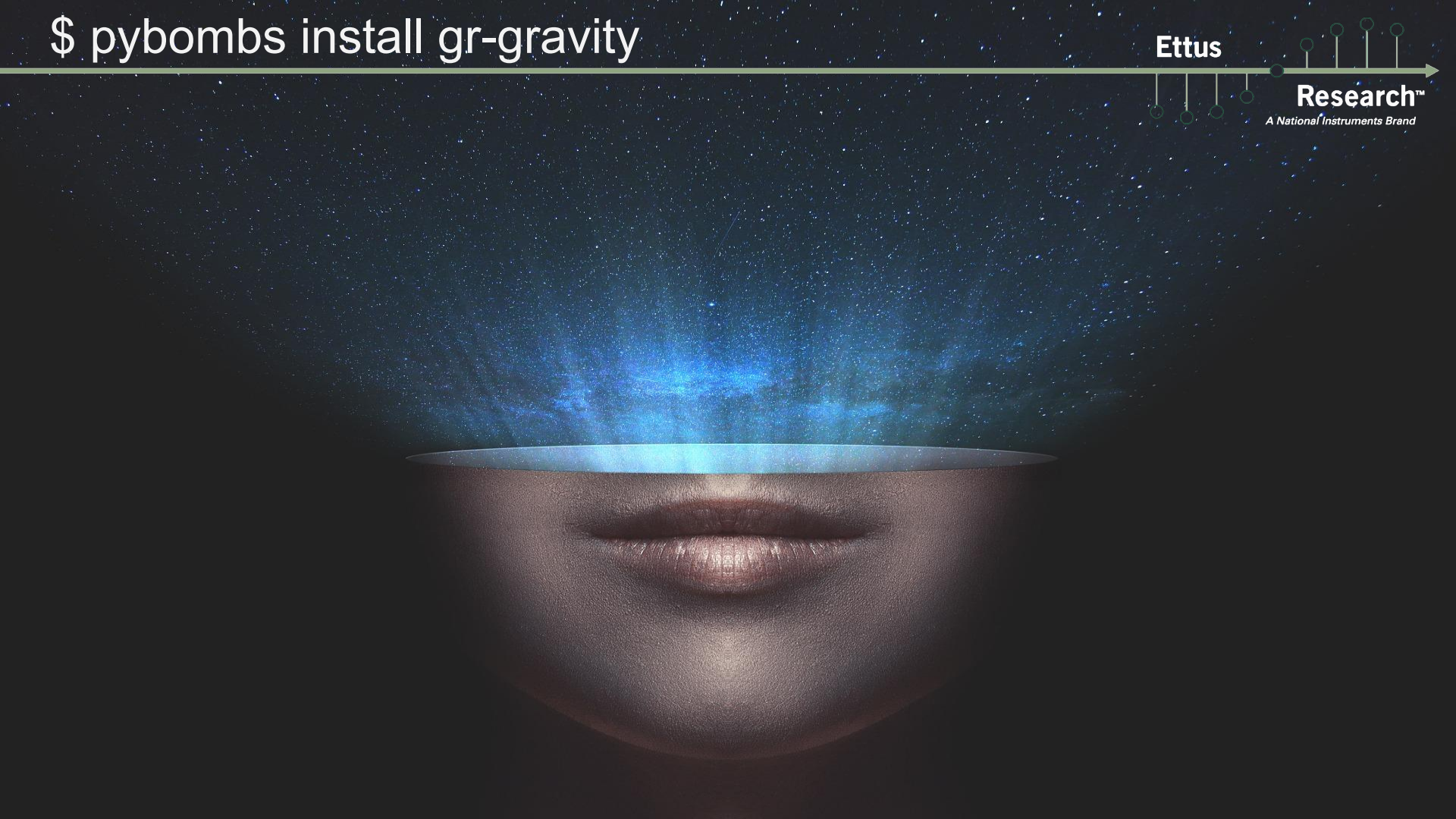

$ gr_modtool newmod gravitron

$ python3 gr-gravity/examples/superpowers.py

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$ universe --set-time now --where here

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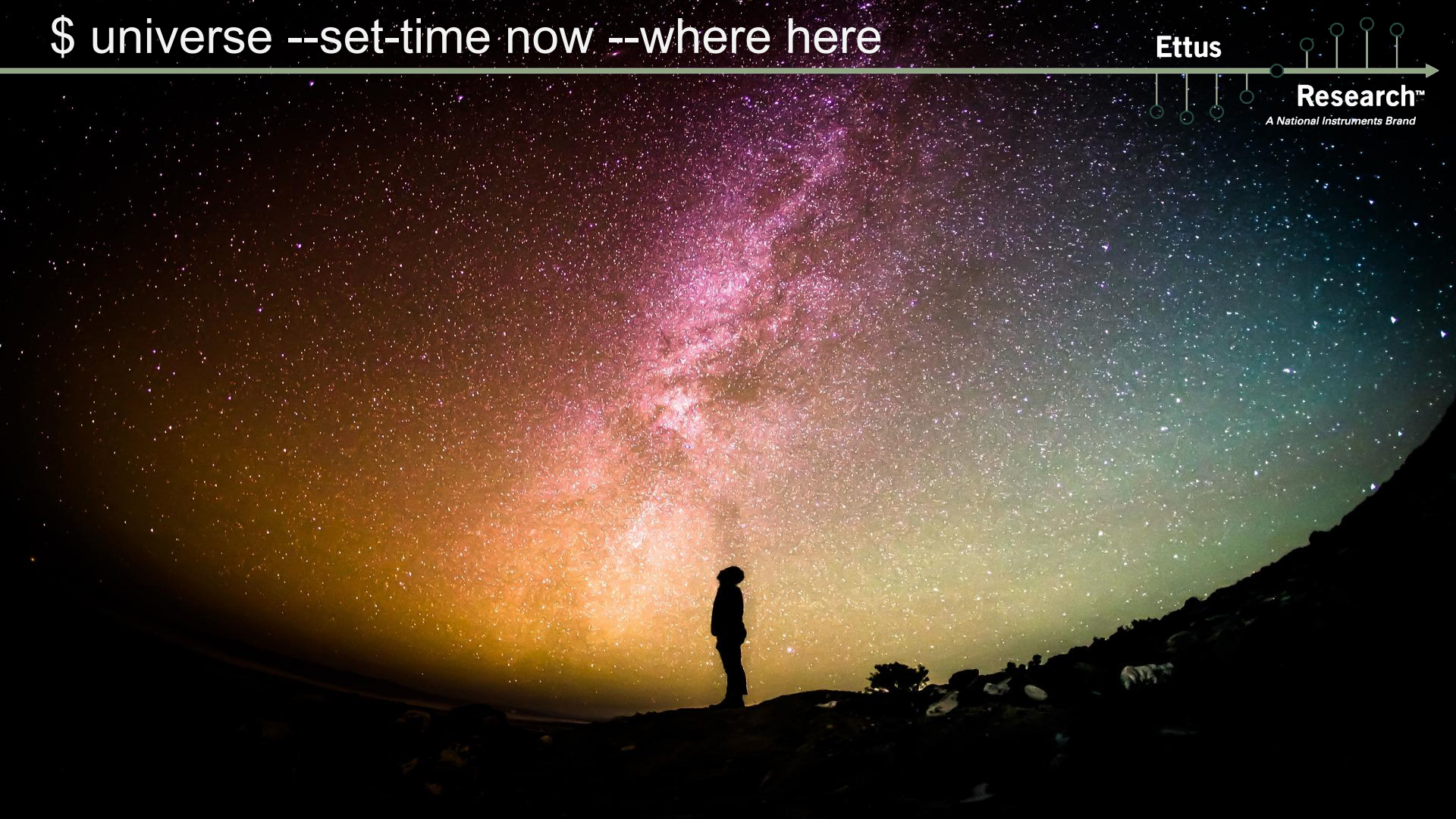

$ universe --check-rules

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What if...

$ universe --check-rules

What if…

- Gravity
- Weak
- Strong
- Electromagnetic

$ universe --check-rules

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What if...

- ~~Gravity~~
- ~~Weak~~
- ~~Strong~~
- Electromagnetic

$ gdb universe --module electromagnetic

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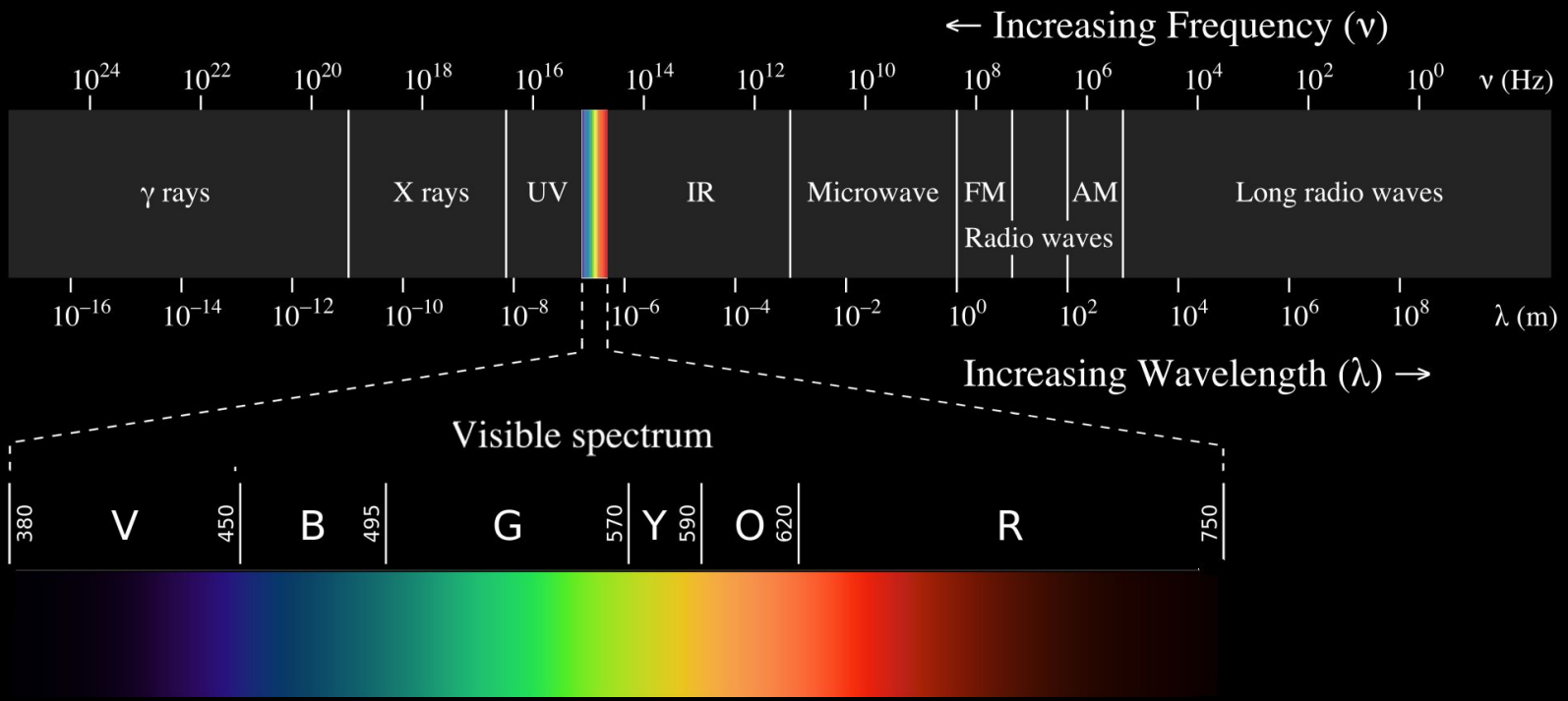

(gdb) next

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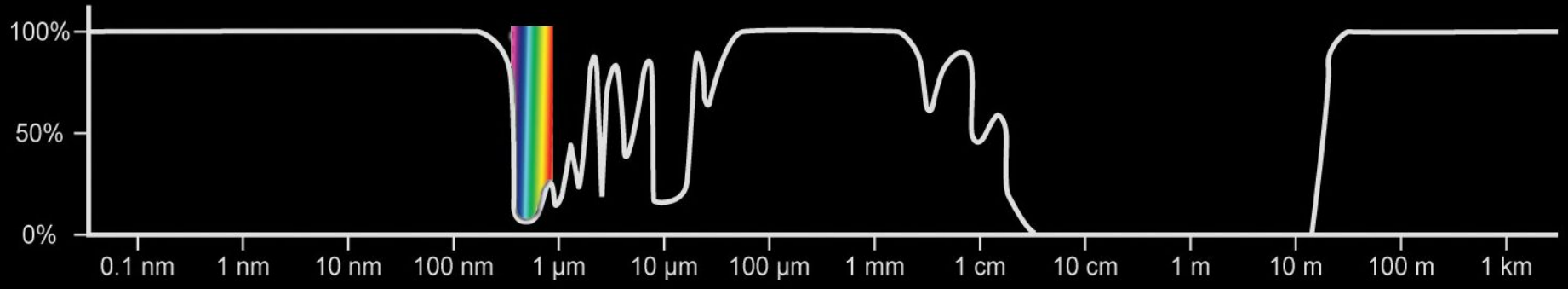

(gdb) break

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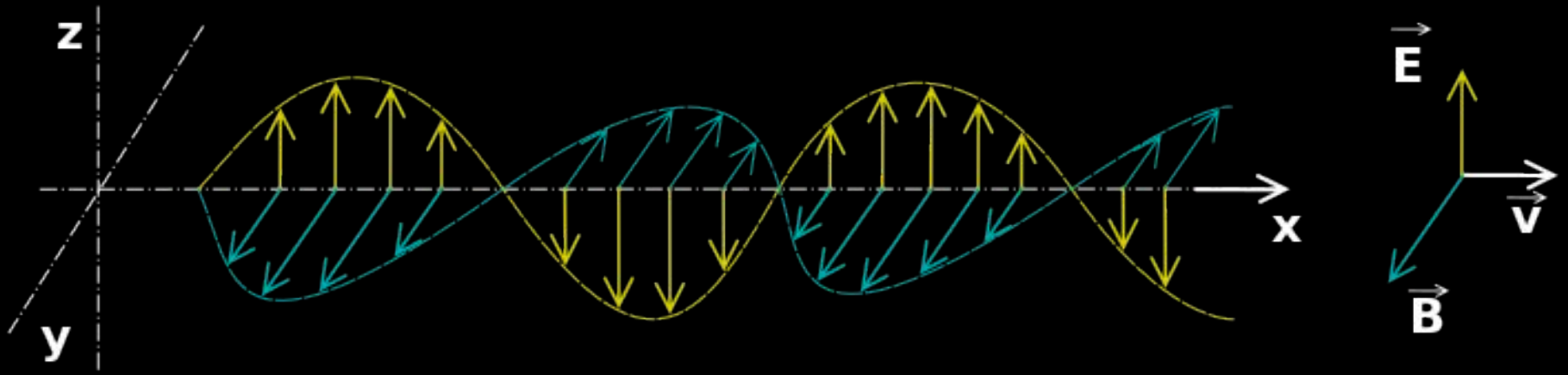

(gdb) run

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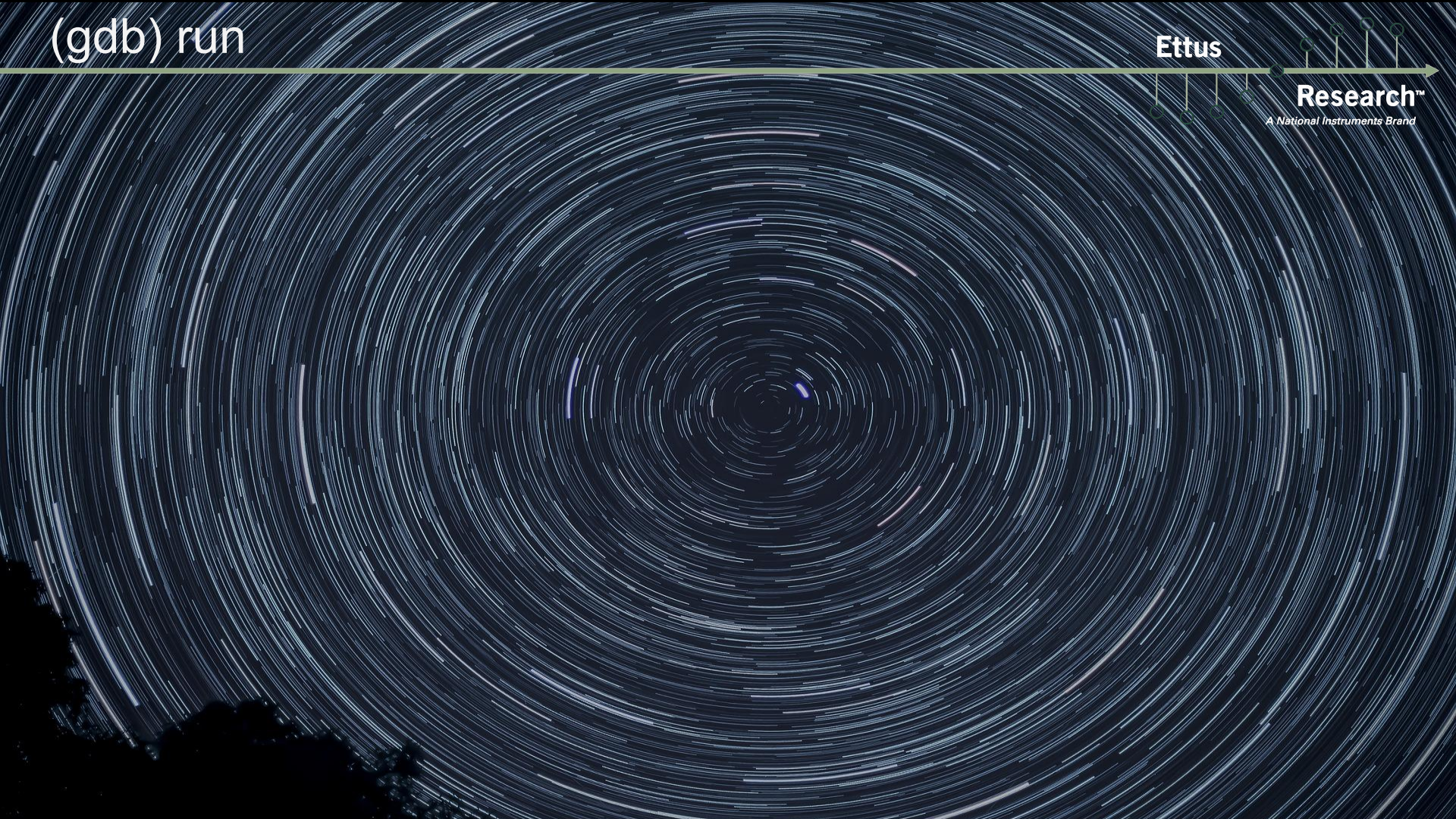

$ cat gr-magic/README.md

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$ cat gr-magic/requirements.txt

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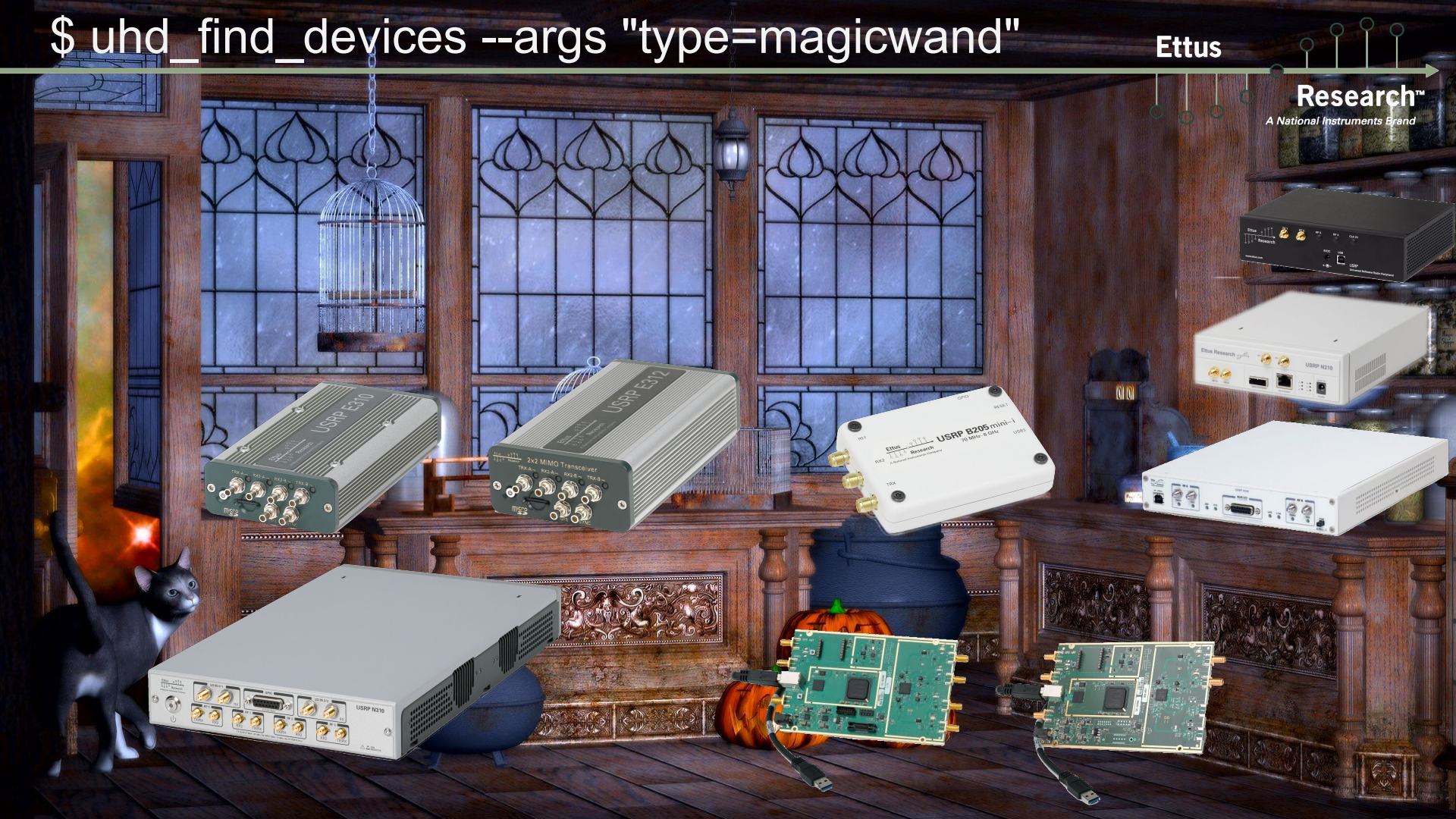
$ uhd_find_devices --args "type=magicwand"



$ uhd_magicwand --help

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$ gnuradio-companion ~/magicspells.grc

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$ cat gr-magic/examples/magic.py

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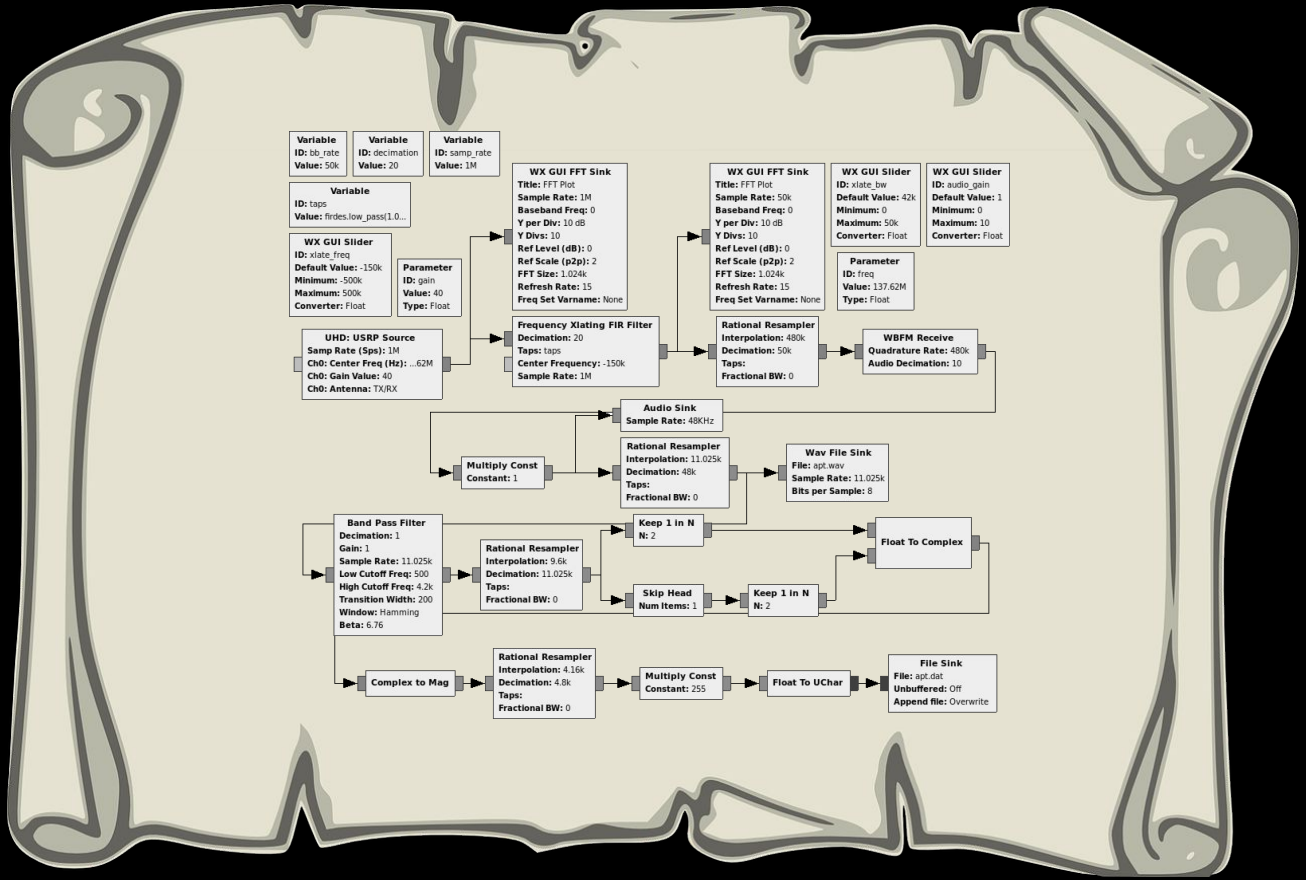

$ gnuradio-companion gr-magic/apps/qt-magicball.grc

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$ gnuradio-companion gr-magic/apps/matrix.grc

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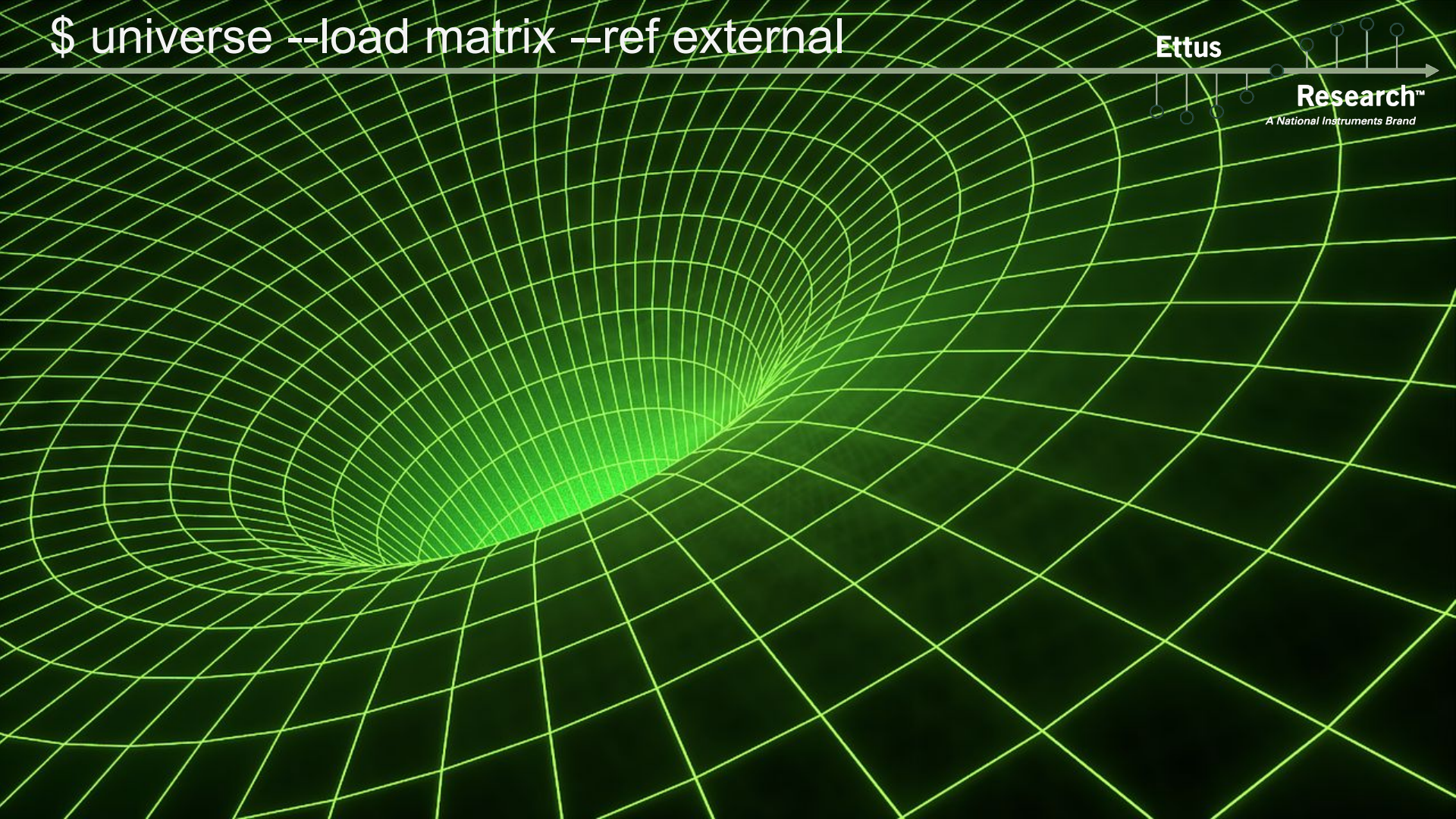
$ universe --load matrix --ref external



USRP1

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USRP1 2001-2017

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USRP1 2001-2017

All good things start with a USRP1 and decimation factor of 20

USRP1 - *The Last Units...*

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If you want one of them, be one of the first five people to compose a USRP1 Haiku and post it ...

USRP1 Haiku

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whizzing through the sky

cubesat pass say hi

you-surp on ground try

USRP1 SatNOGS Station

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SatNOGS

$ universe --snapshot earth

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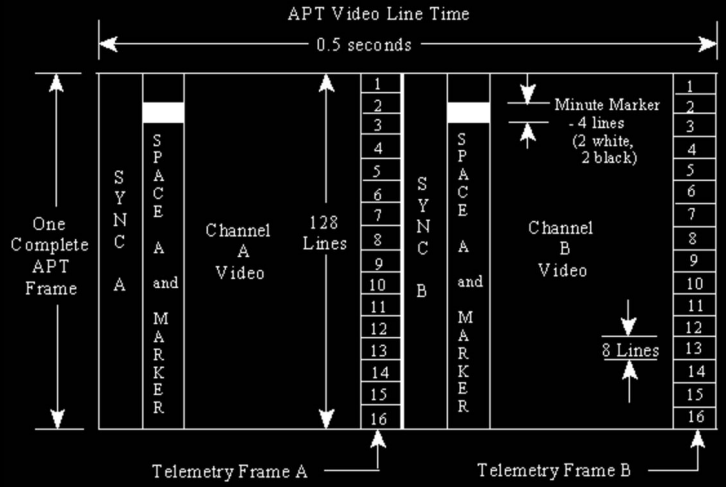
- Automatic Picture Transmission (APT)
- Introduced in the 1960s
- Provides image data to relatively low-cost stations
- Broadcasted by NOAA-15, NOAA-18, NOAA-19
- Data transmitted as a horizontal scan line
- Complete line is 2080 pixels long
- Transmitted at 2 lines per second (4160 baud)
- 8 bit grayscale
- Pixel intensity is AM modulated on a 2.4 kHz tone
- Then FM modulated on 137 MHz carrier
- 4 km / pixel
- wikipedia.org/wiki/Automatic_picture_transmission

Figure 4.2.2-1. APT Frame Format.



WEDGE #1	WEDGE #2	WEDGE #3	WEDGE #4	WEDGE #5	WEDGE #6	WEDGE #7	WEDGE #8
1	2	3	4	5	6	7	8
Zero Modulation Reference	Thermistor Temp. #1	Thermistor Temp. #2	Thermistor Temp. #3	Thermistor Temp. #4	Patch Temp.	Back Scan	Channel I.D. Wedge
9	10	11	12	13	14	15	16

Notes:
1) Each telemetry frames consists of 16 points
2) Telemetry frame rate is 1 frame per 84 seconds
3) Each telemetry point is repeated on 8 successive APT video lines

APT

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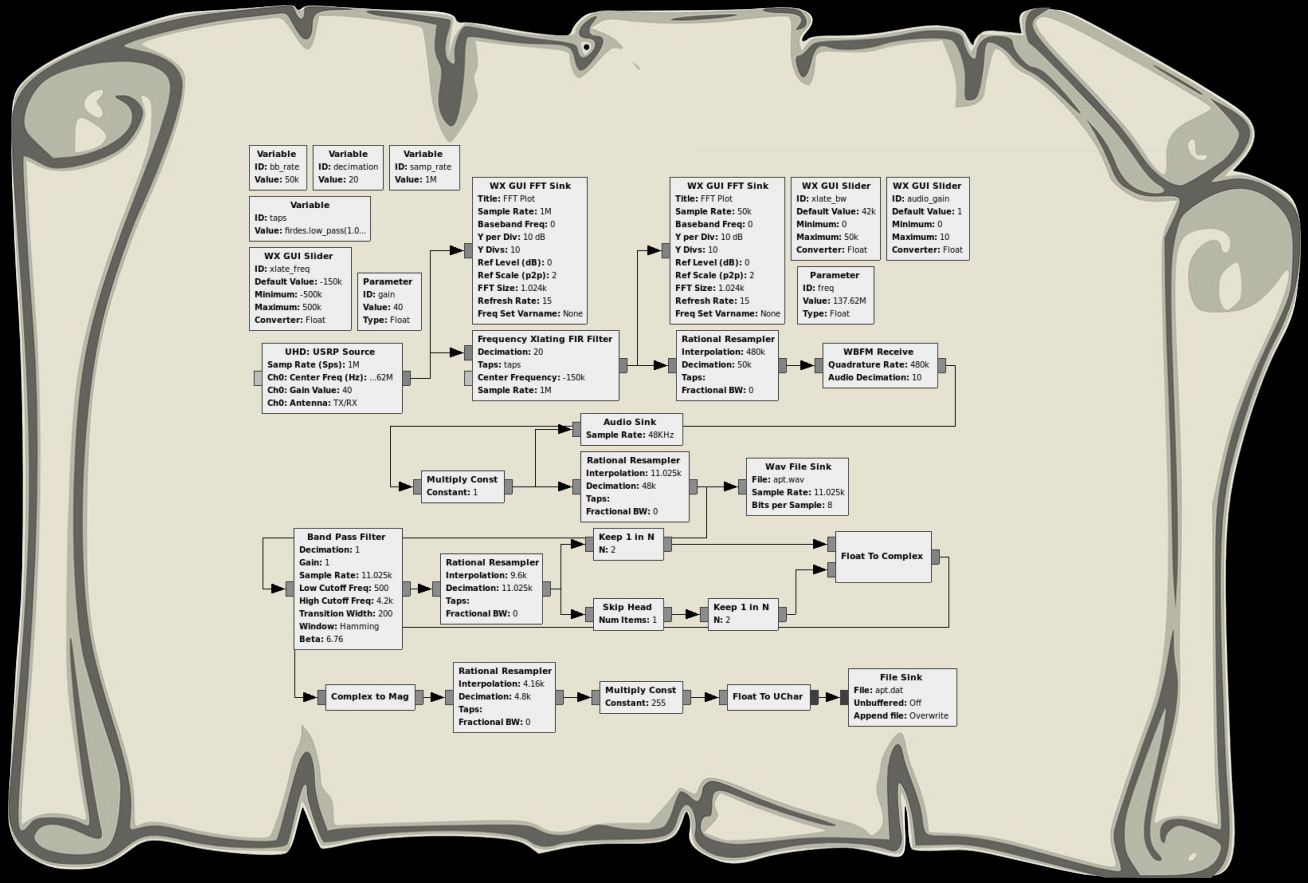

APT

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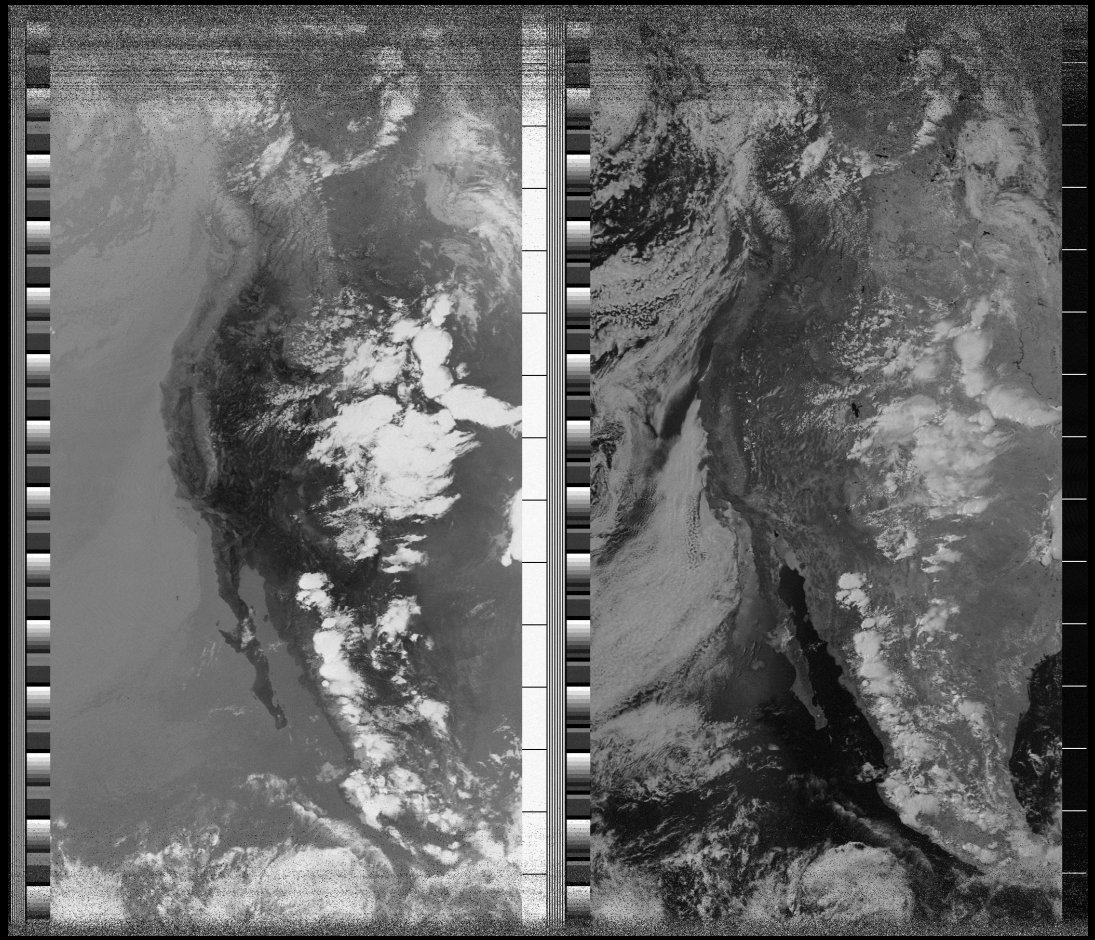

APT

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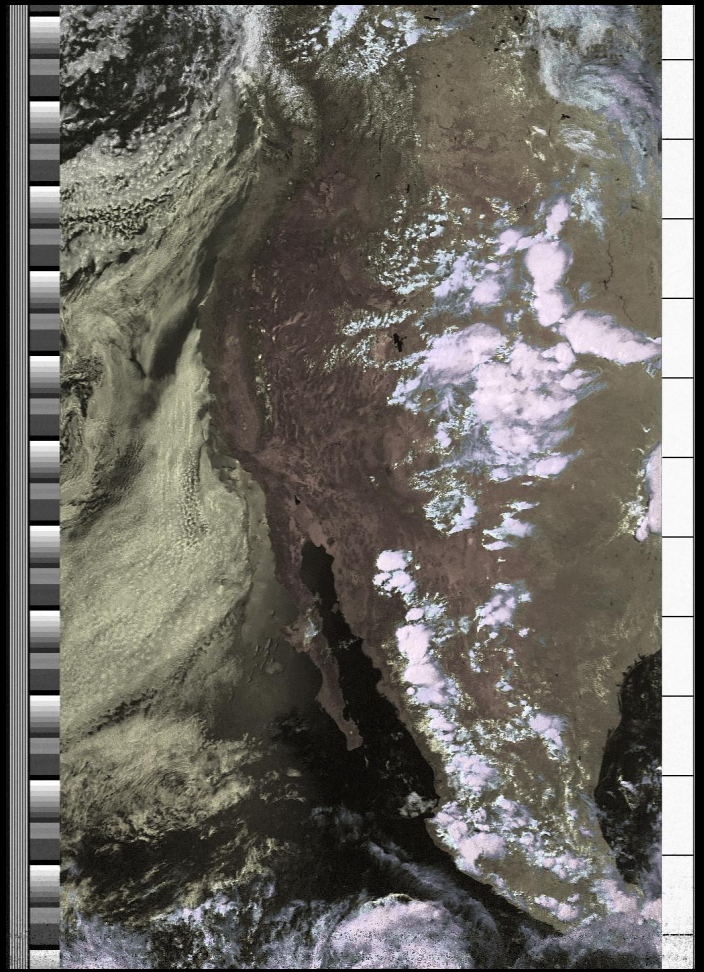

LRPT

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- Low-Rate Picture Transmission (LRPT)
- Digital transmission system, intended to deliver images and data from weather satellites
- Active on Meteor M2 at 137.9 MHz
- Three spectral channels
- 1km / pixel resolution
- QPSK modulation 72k baud
- Flowgraphs based on Otti's implementations
- `https://github.com/otti-soft/meteor-m2-lrpt`
- Flowgraphs creates .s (soft symbols) file
- Symbols (.s) file can then be processed by **`meteor_decoder`** utility by artlav
- `https://github.com/artlav/meteor_decoder`

LRPT

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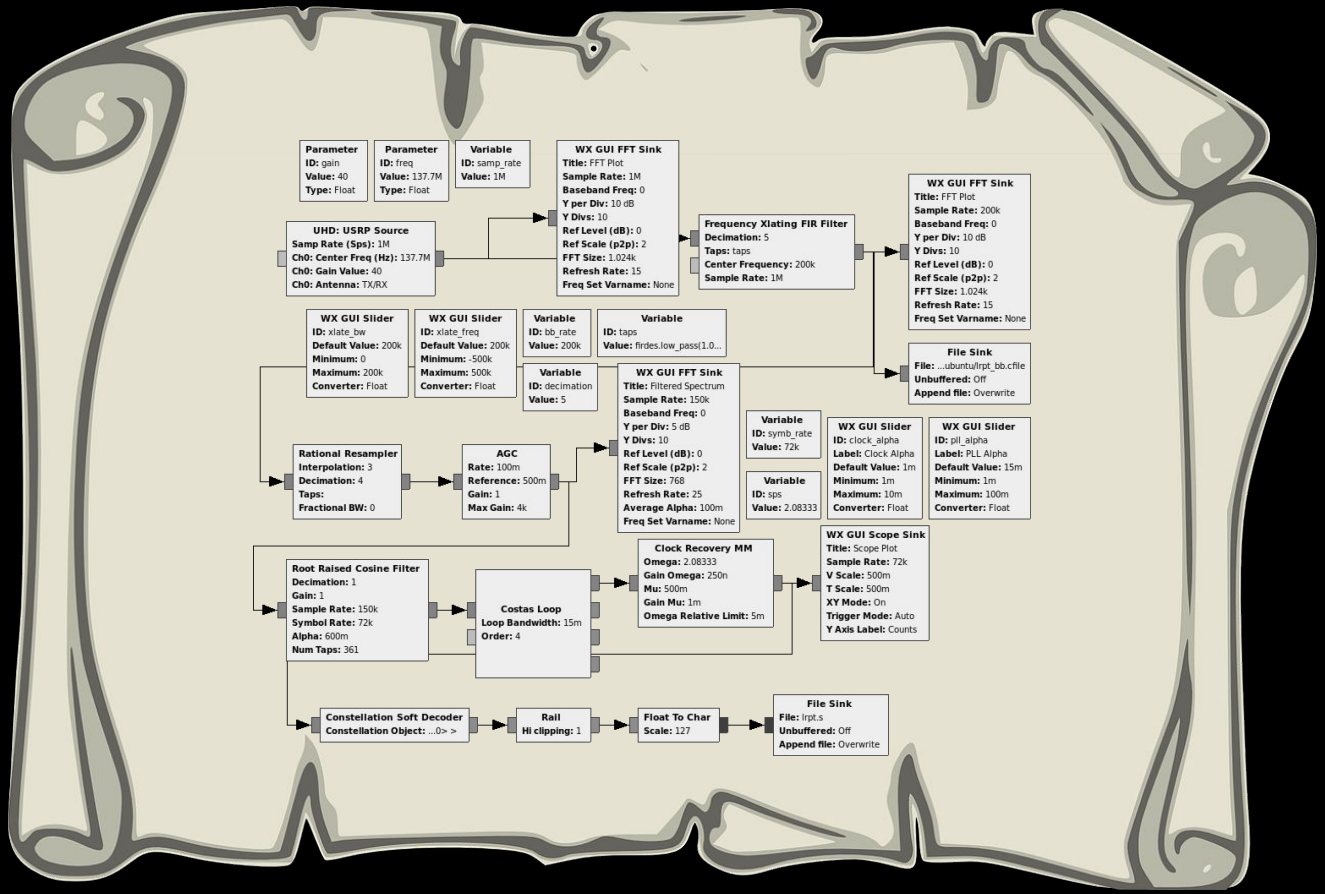

LRPT

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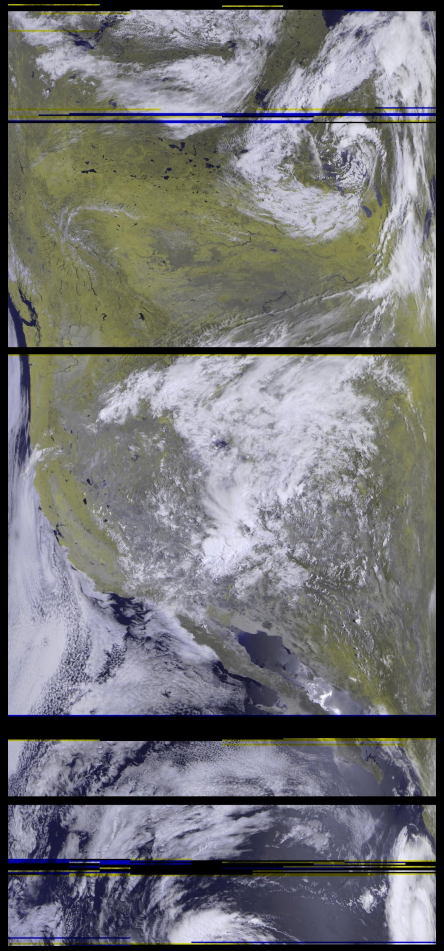

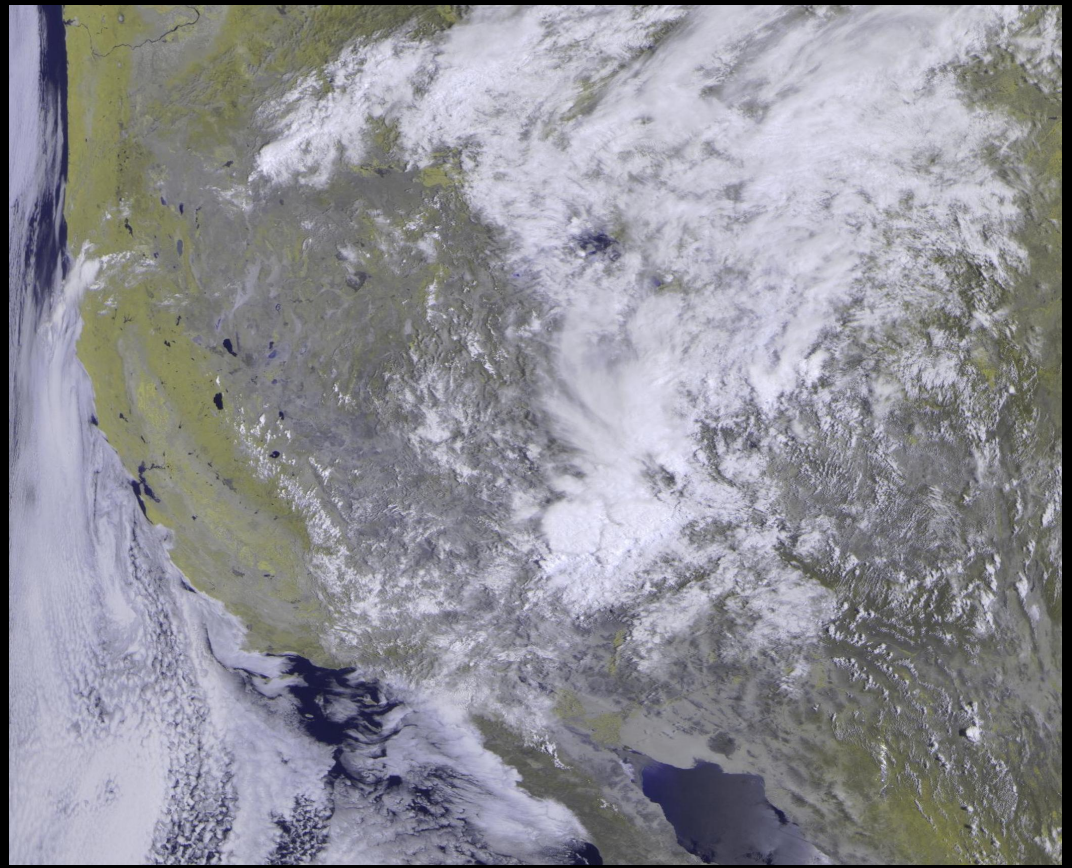

HRPT

Ettus Research™
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- High-Rate Picture Transmission (HRPT)
- Intended to deliver images and data from an orbital weather satellites

- NOAA-15, NOAA-18, NOAA-19 (USA)
- Meteor M2 (RUSSIA)
- Feng-Yun (CHINA)

- L-Band - 1.7 GHz

- Requires Dish & Tracking Mount

DIY AzEI

HRPT

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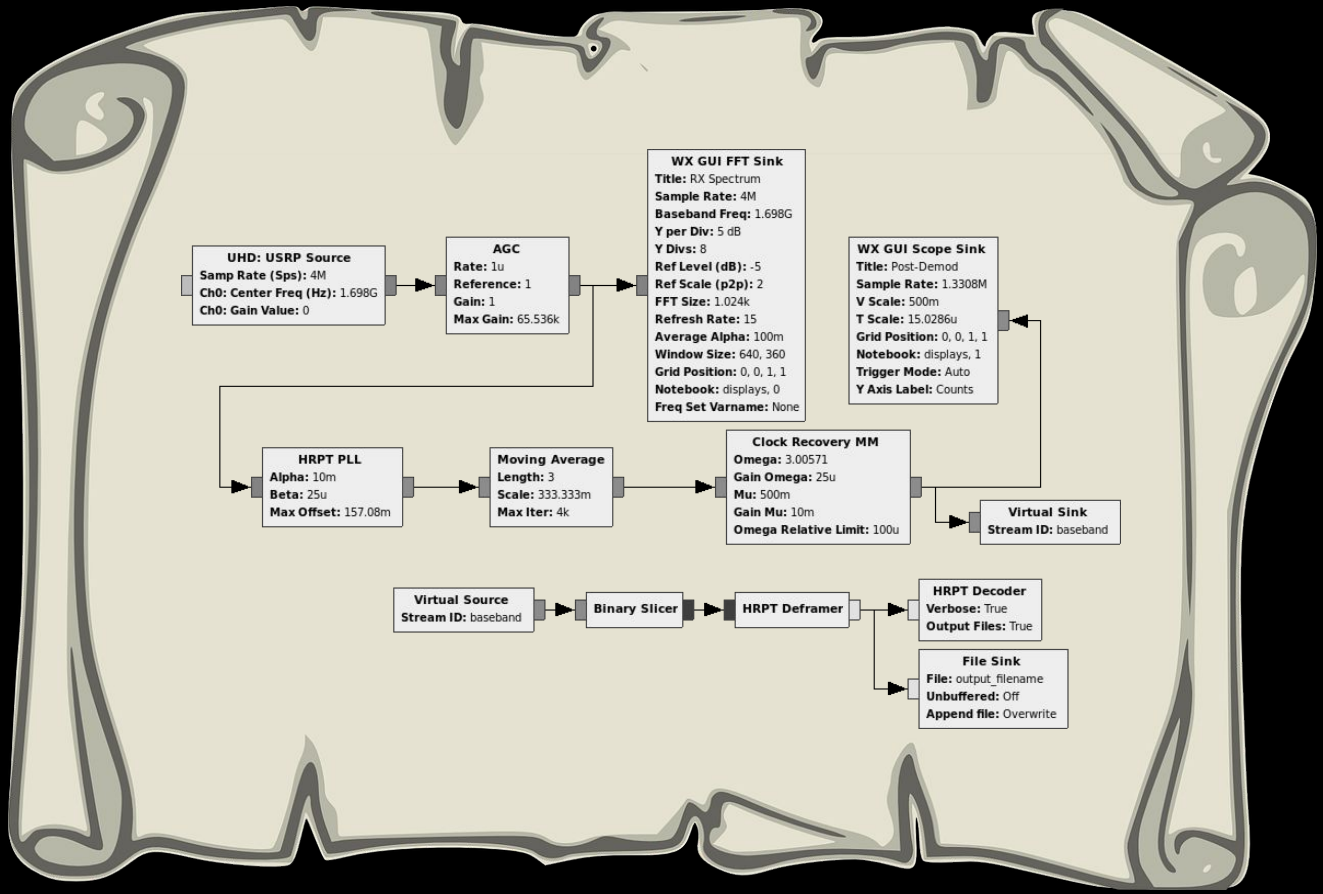

HRPT

Ettus Research™
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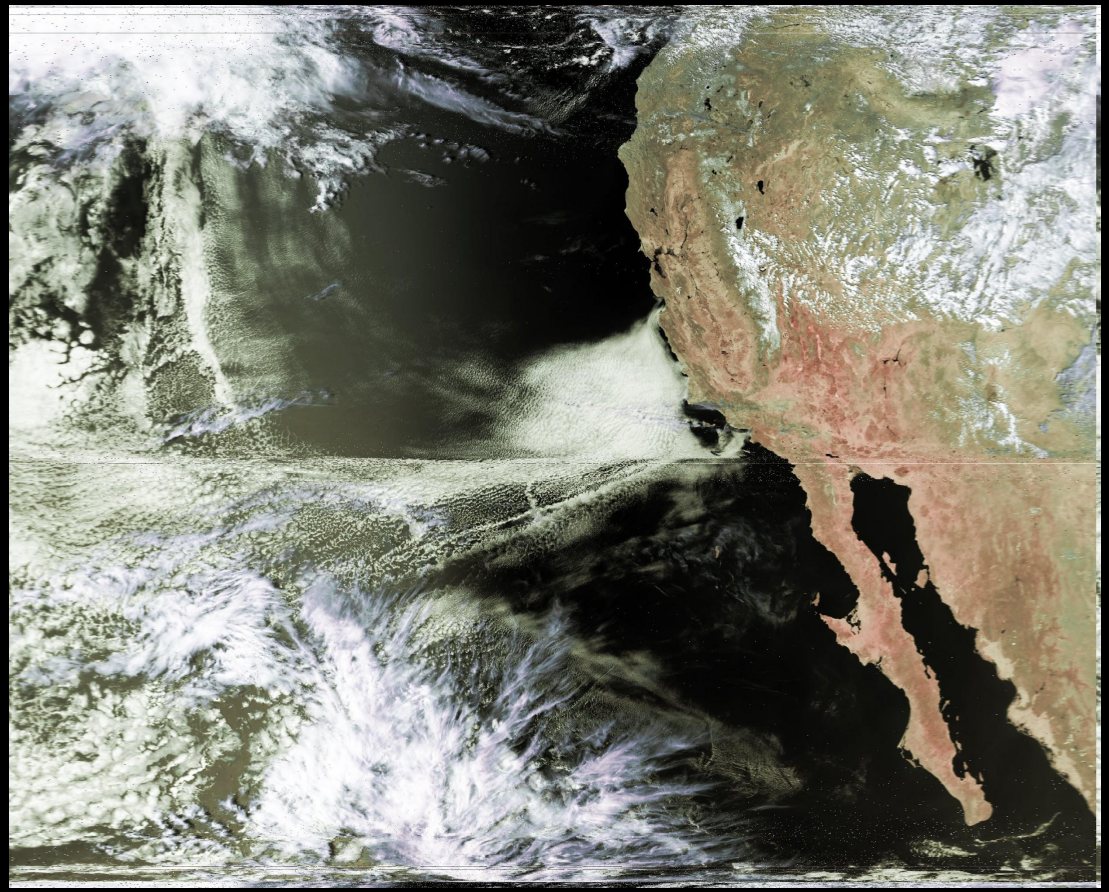

HRPT

Ettus Research™
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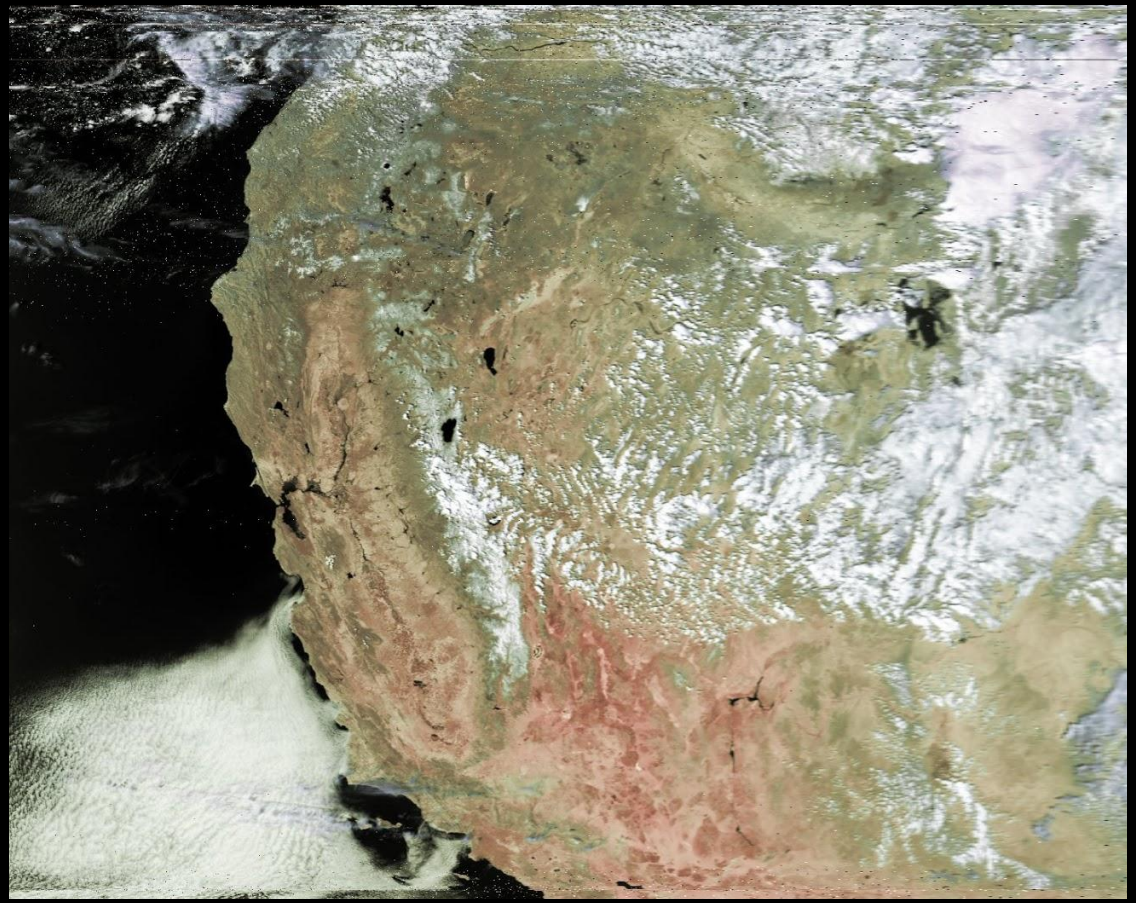
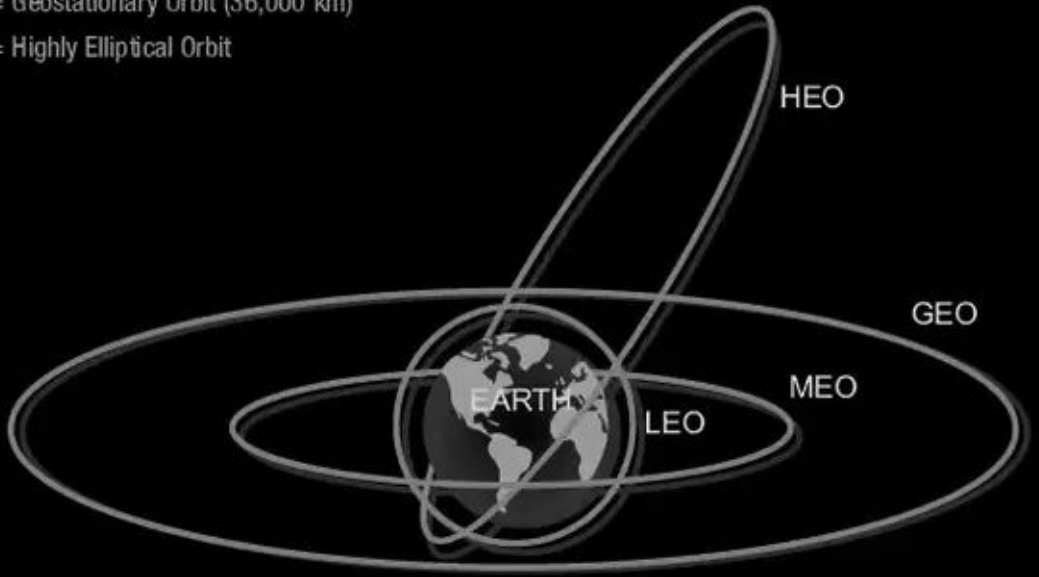


LRIT / HRIT

- Low-Rate Information Transmission
- High-Rate Information Transmission
- LRIT - GOES-13,14,15
- HRIT - GOES-16,17

LEO = Low Earth Orbit (100-1,500 km)
MEO = Medium Earth Orbit (5,000-10,000 km)
GEO = Geostationary Orbit (36,000 km)
HEO = Highly Elliptical Orbit



LRIT - Open Satellite Project

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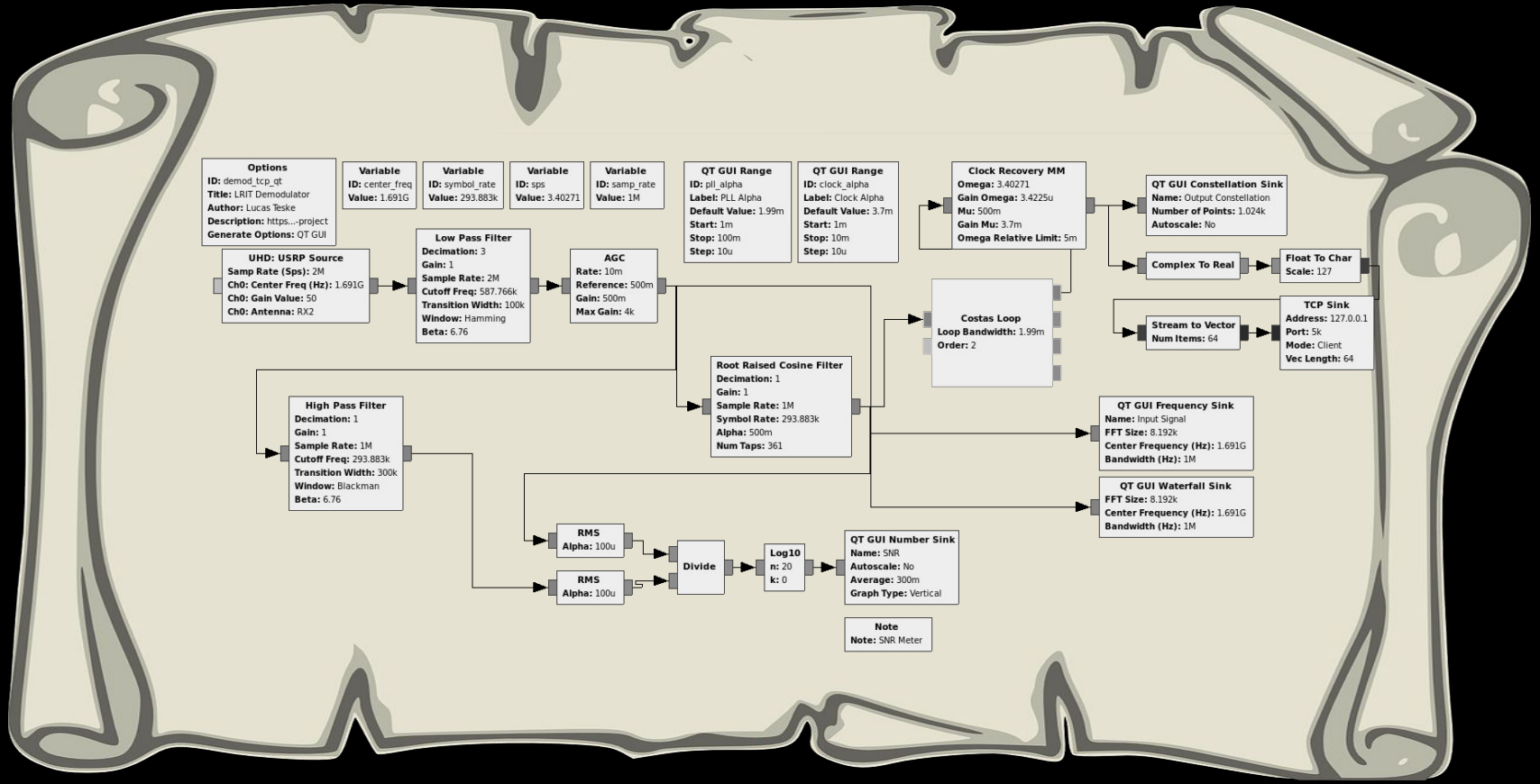

LRIT

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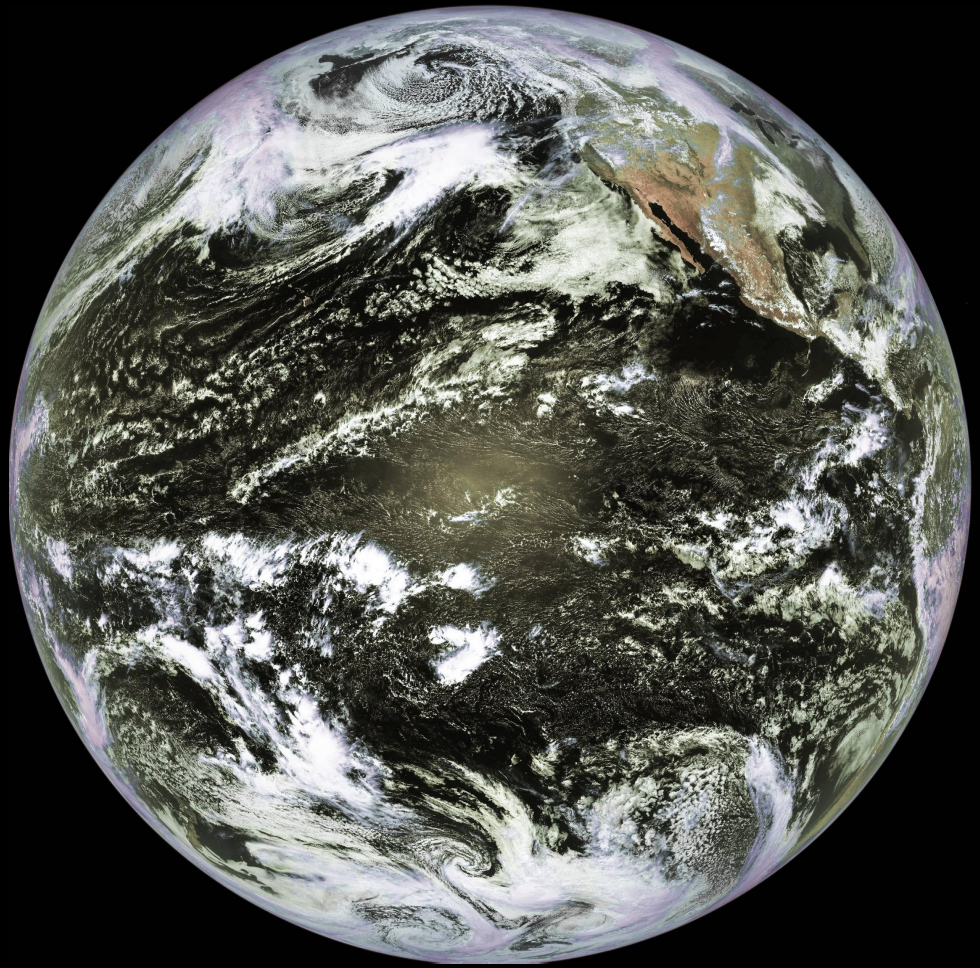
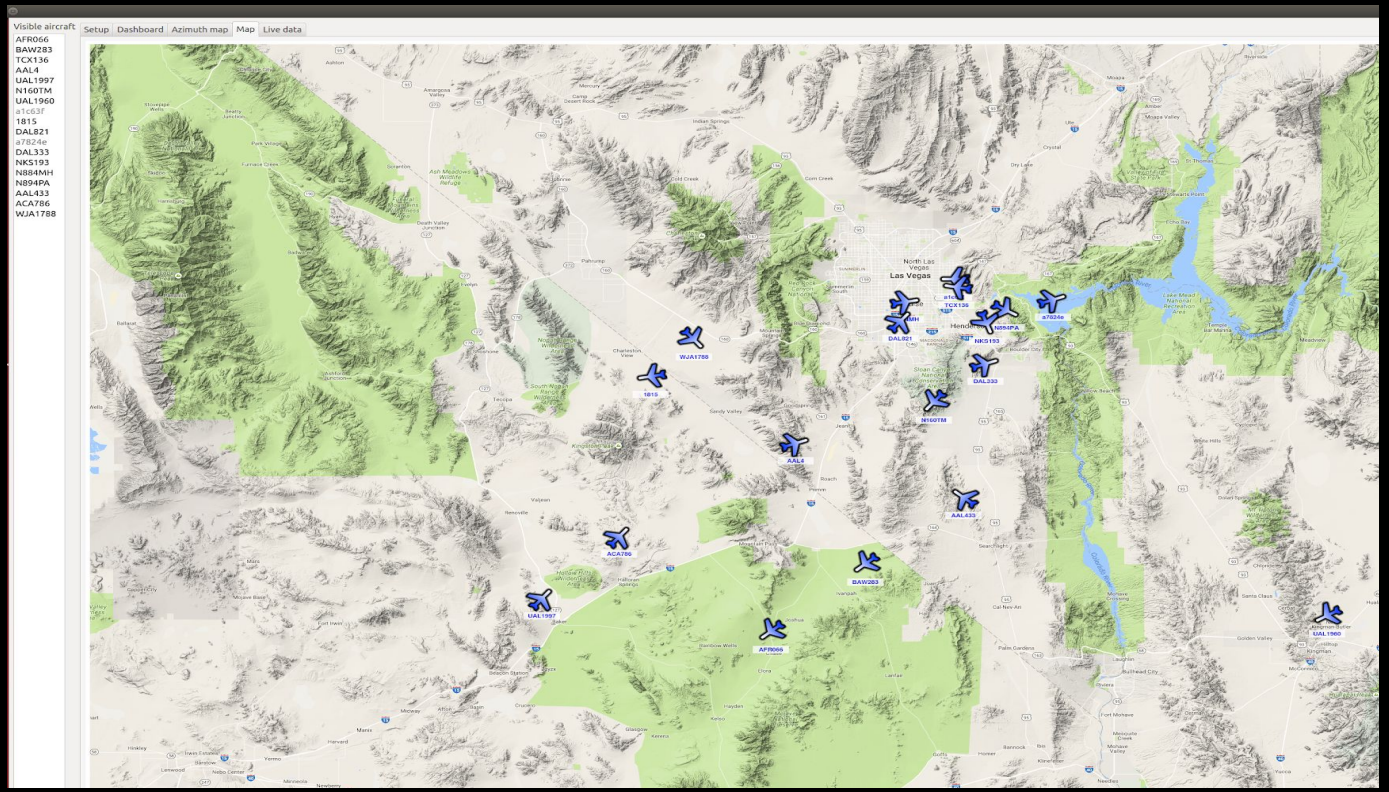


ADS-B

- gr-air-modes (https://github.com/bistromath/gr-air-modes)
- gr-adsb (https://github.com/wnagele/gr-adsb)



ATSC

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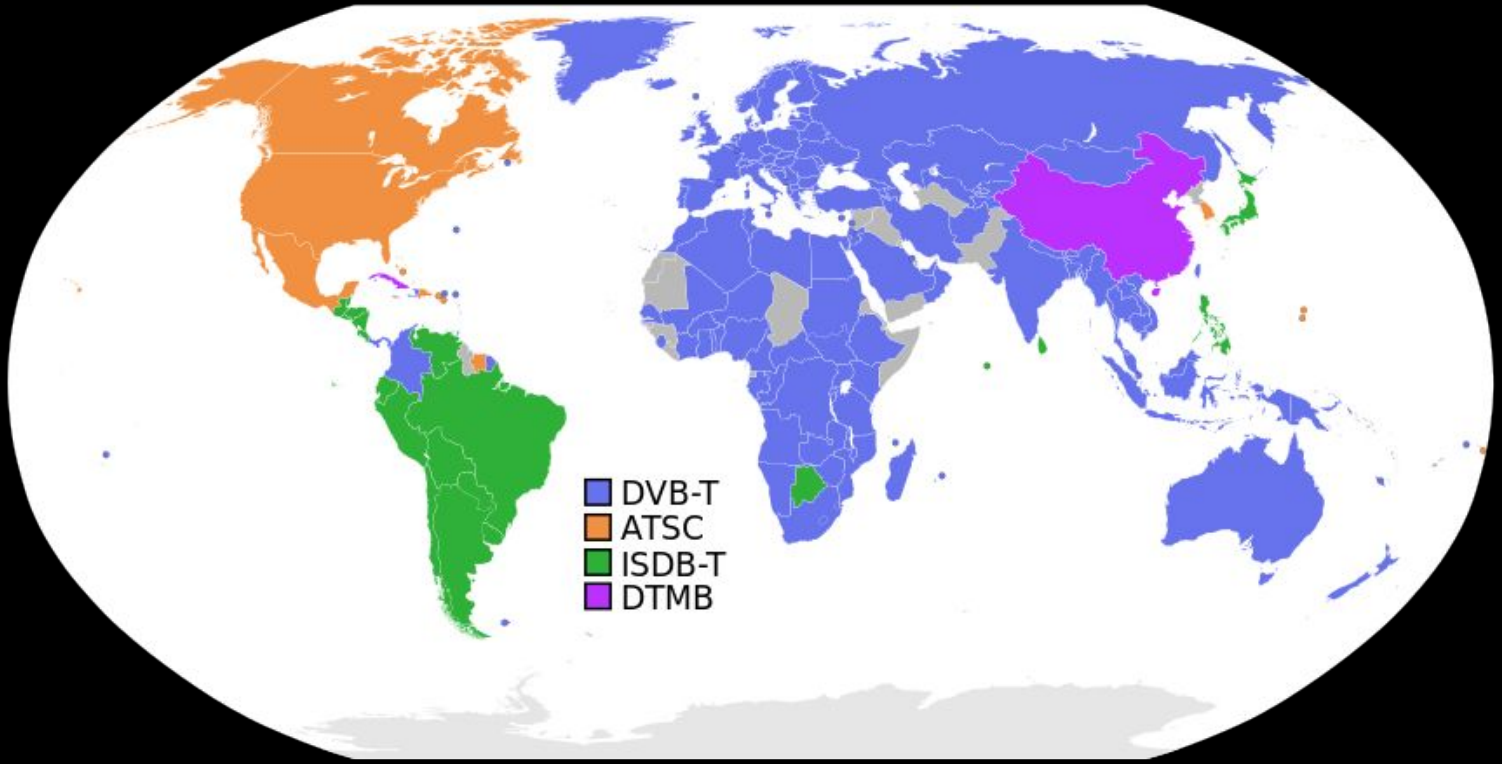
- Advanced Television Systems Committee (ATSC) standards are a set of standards for digital television transmission over terrestrial, cable, and satellite networks.
- Free "Over-The-Air" TV



ATSC

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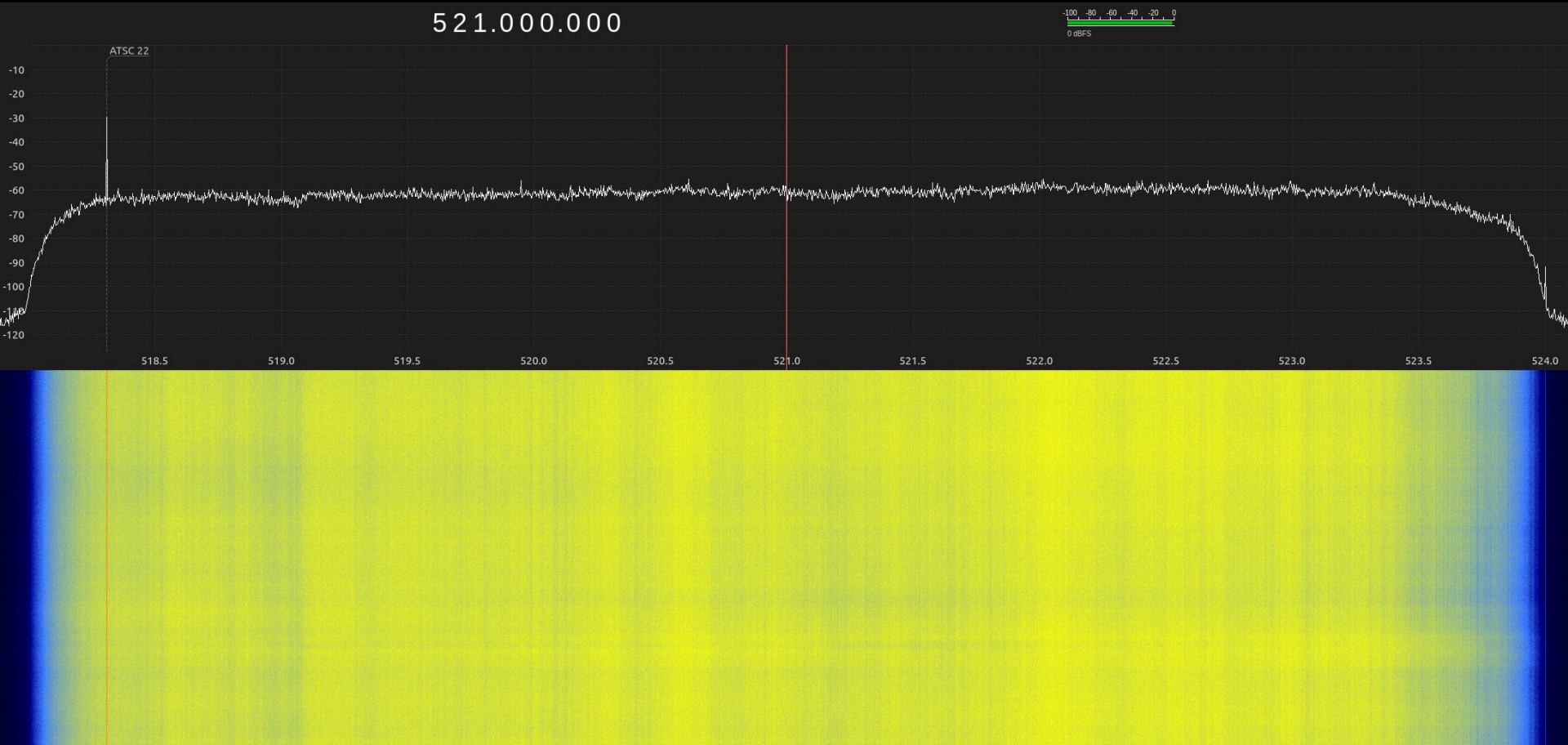

ATSC

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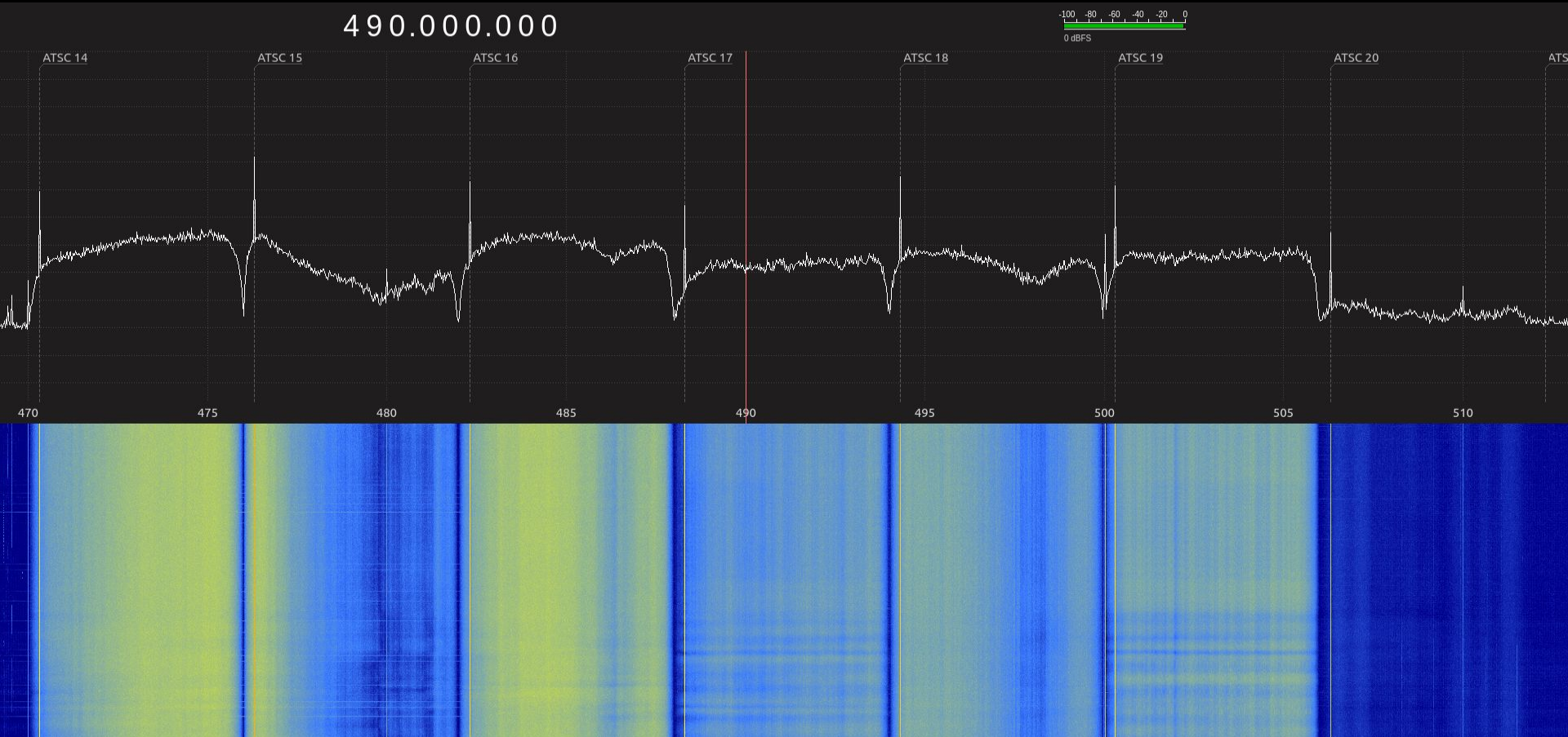
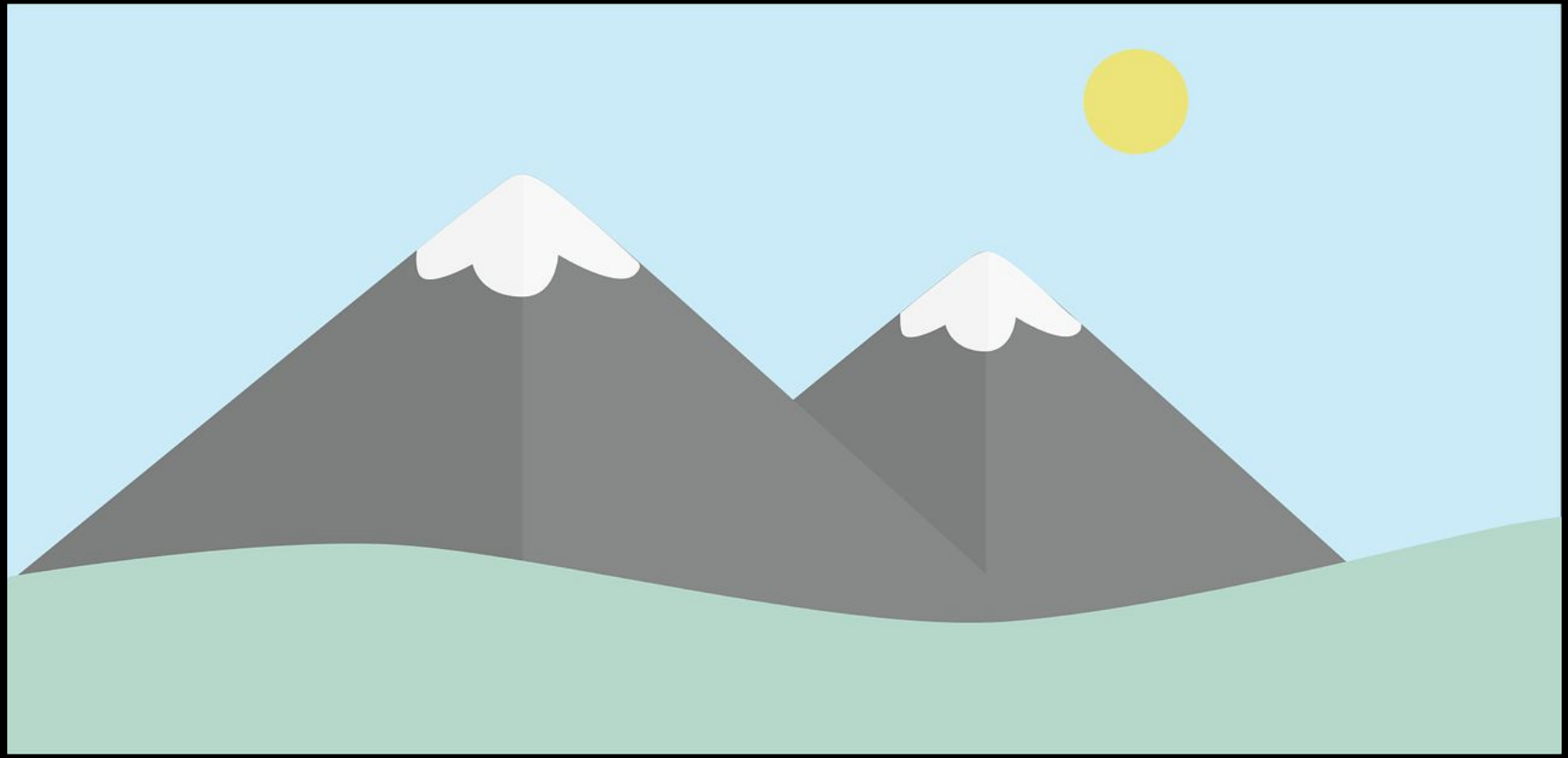
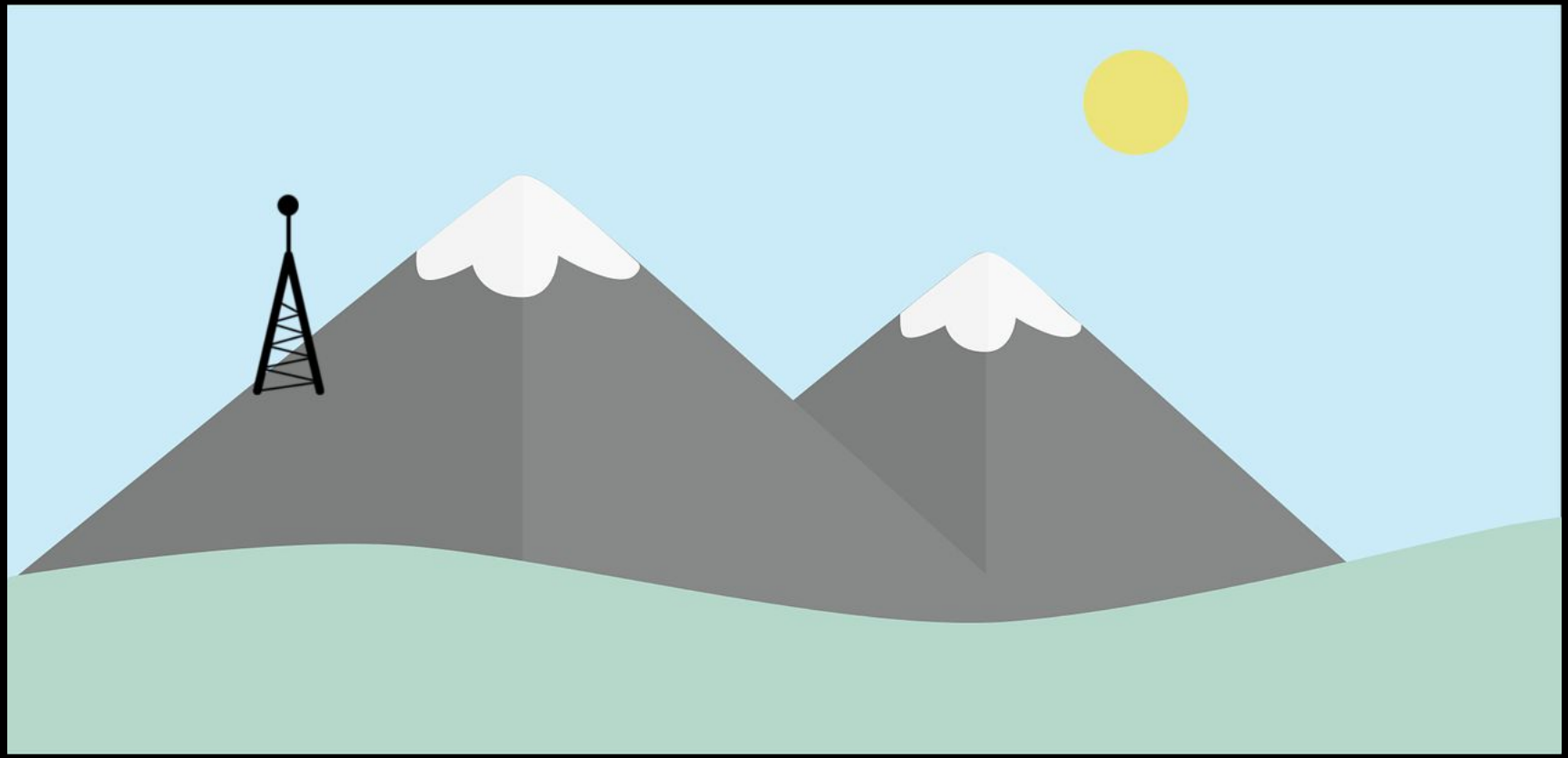




ATSC



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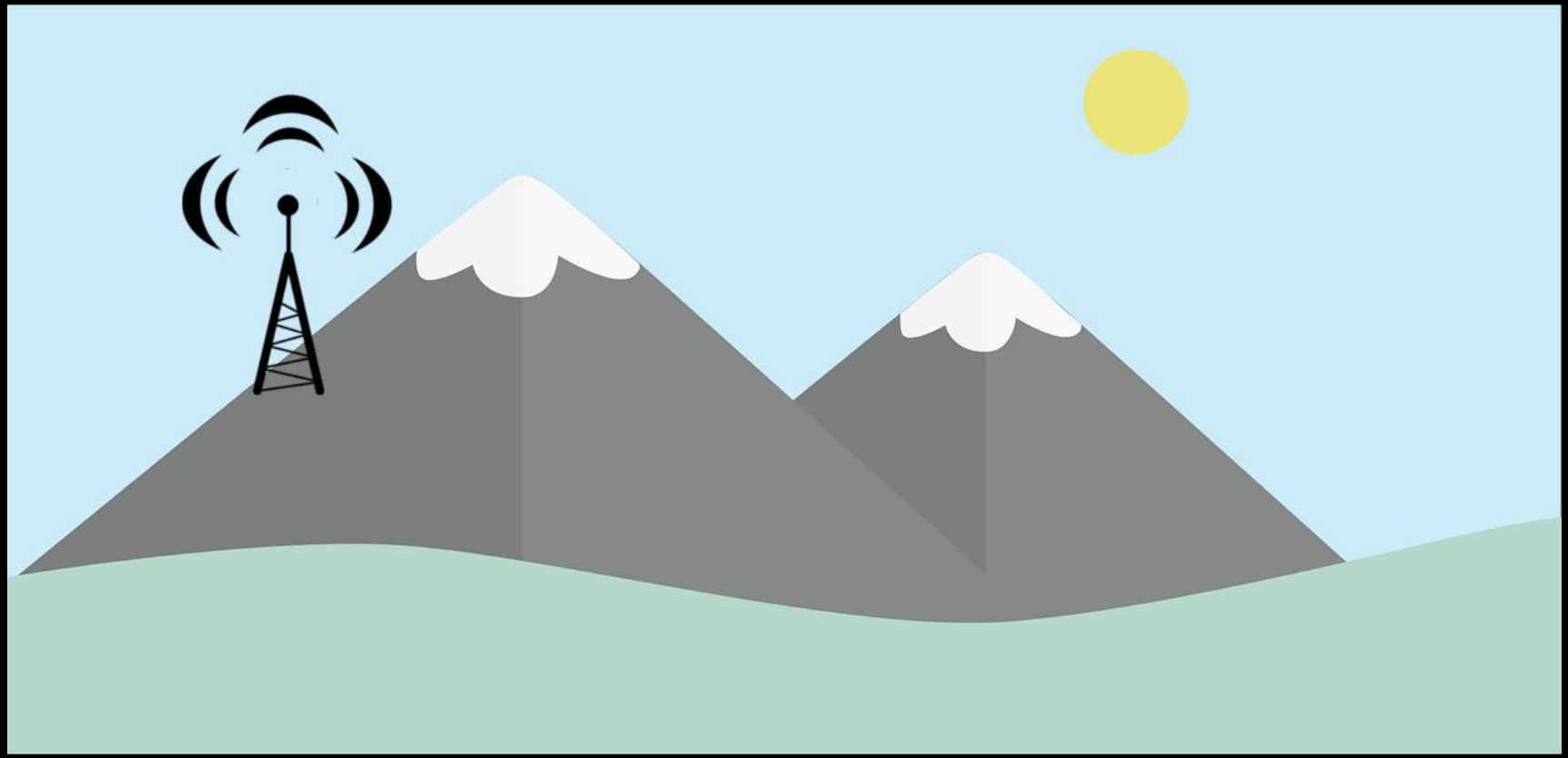
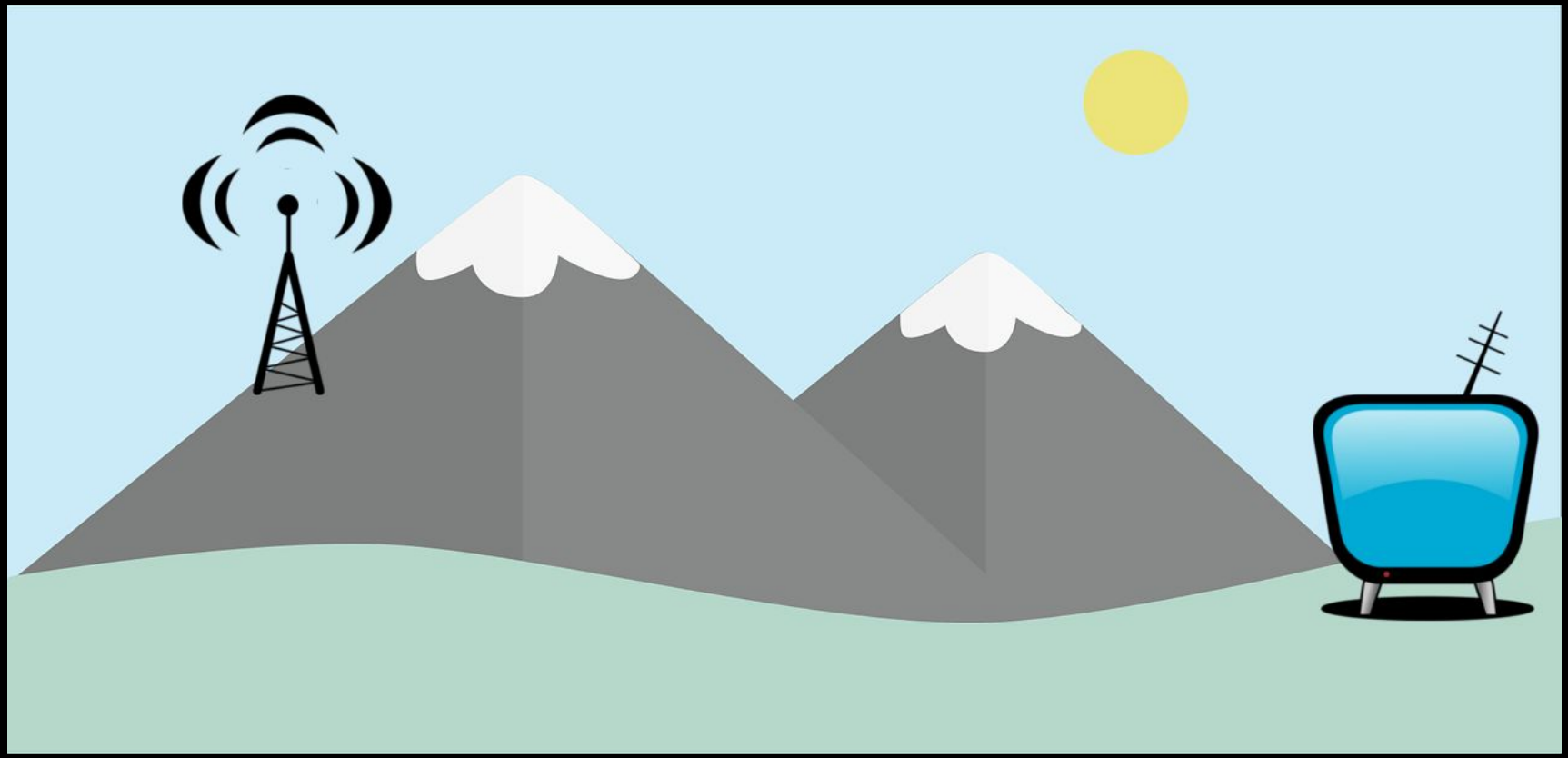


ATSC



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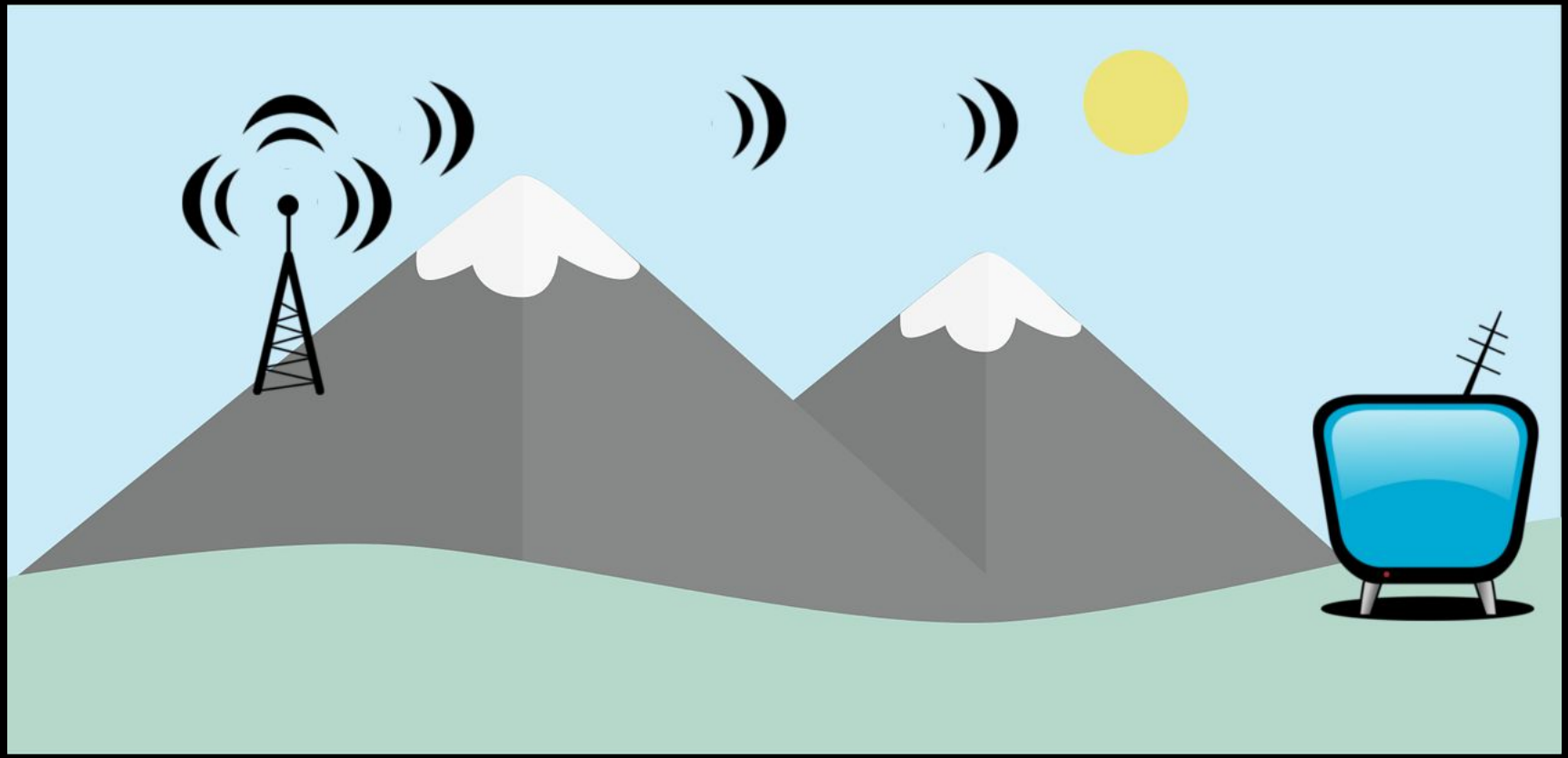
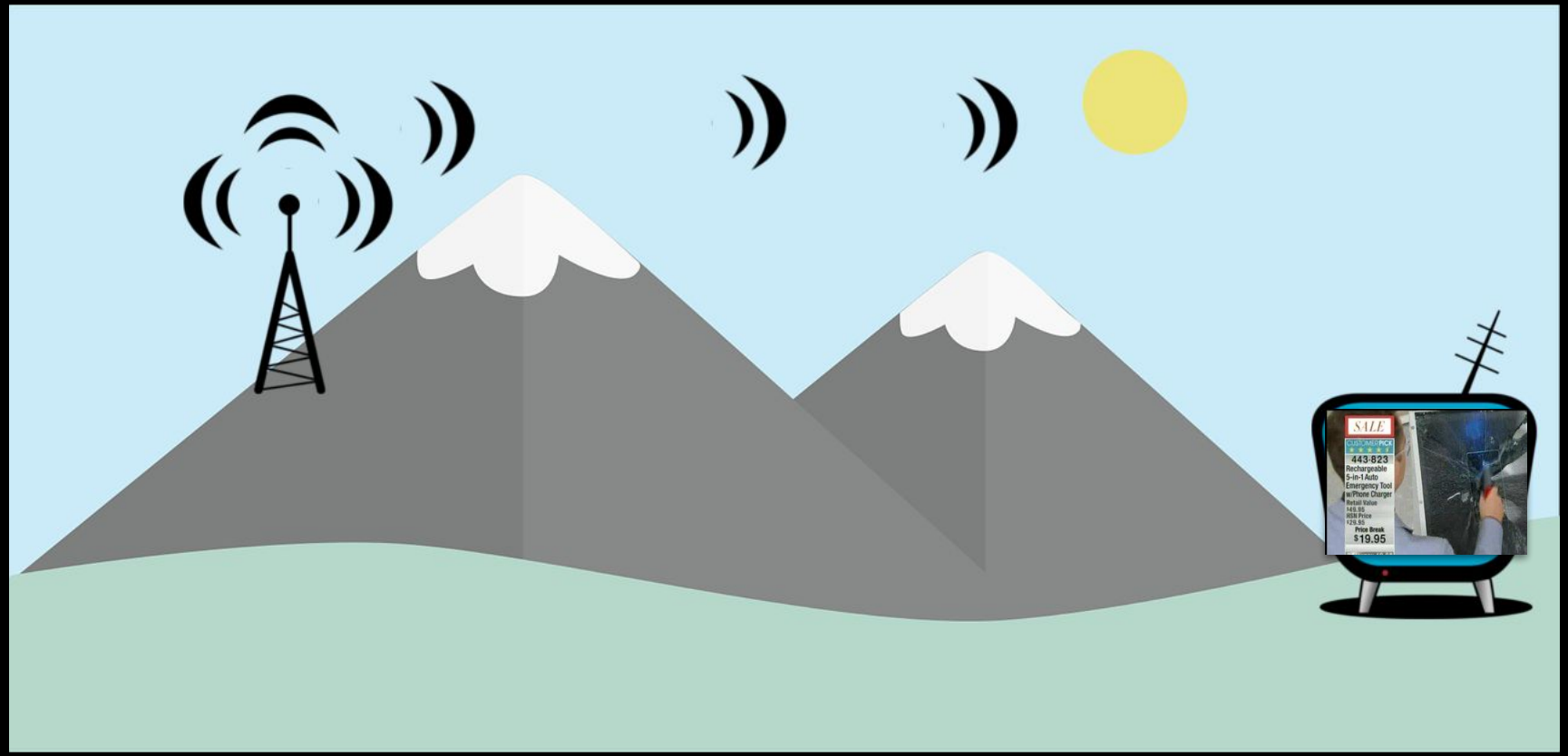


ATSC


SALE
443-823
Rechargeable
5-in-1 Auto
Emergency Tool
w/Phone Charger
Retail Value
$49.95
HSN Price
$29.95
Price Break
$19.95

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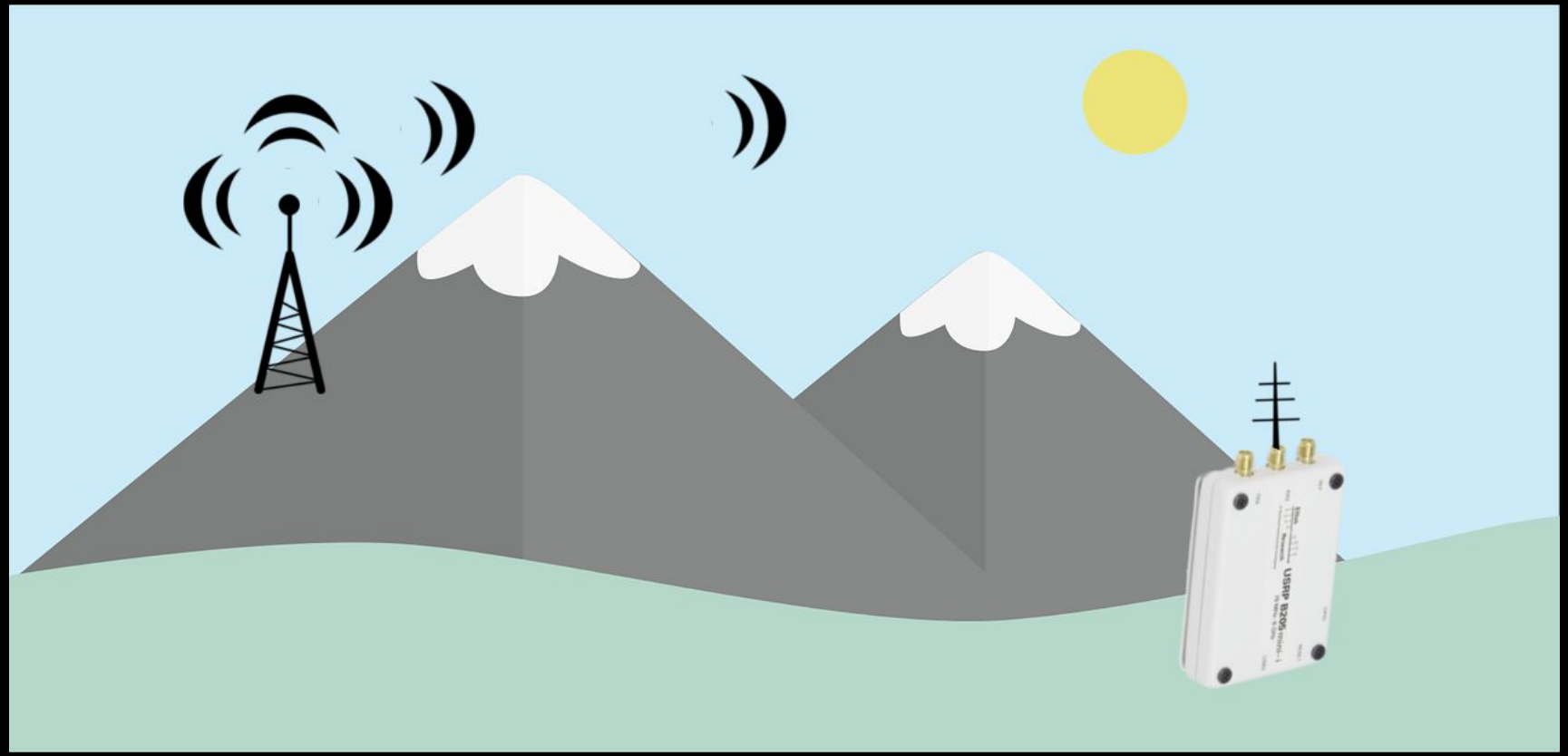

gr-atsc flowgraph

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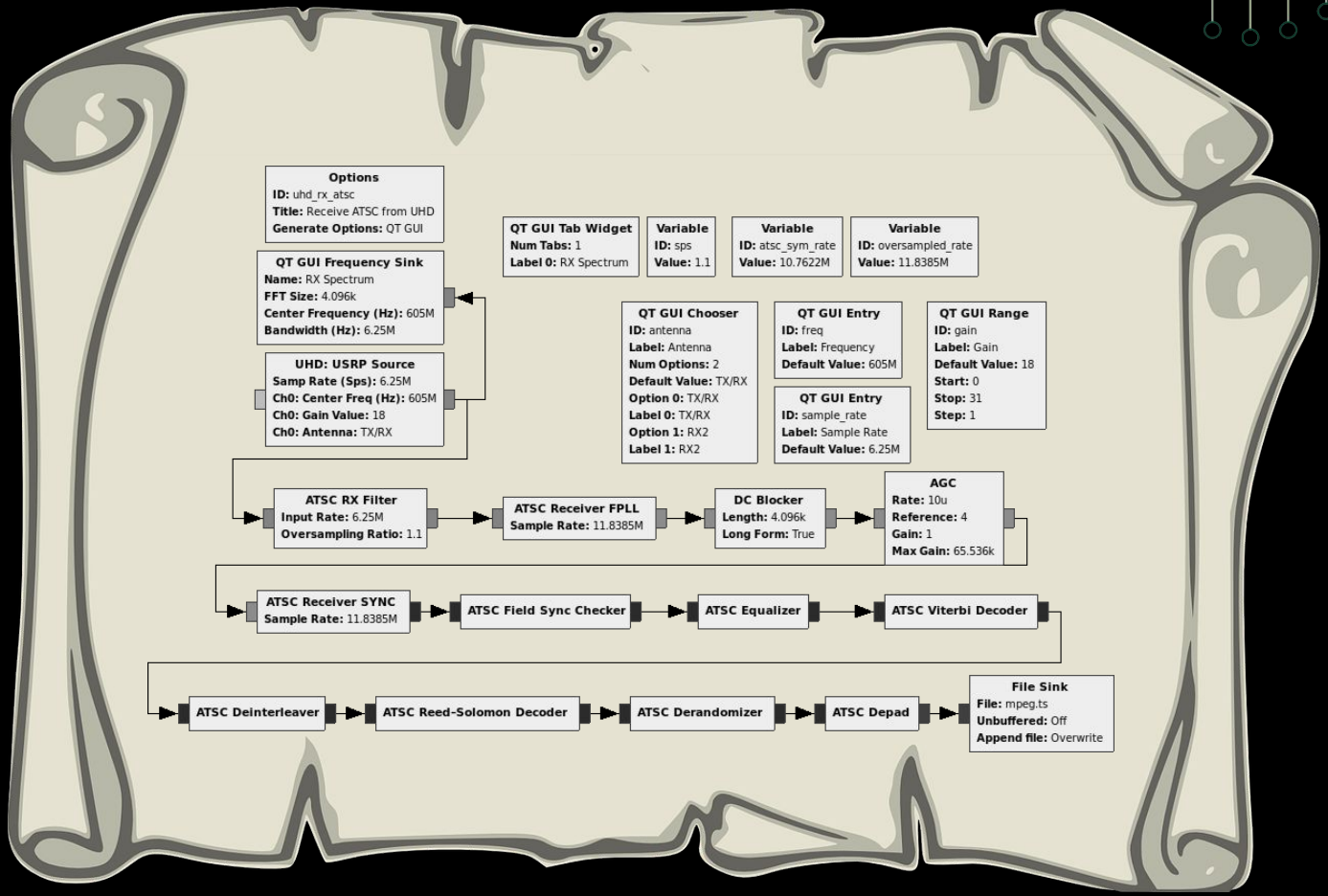

gr-atsc

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ATSC Signal

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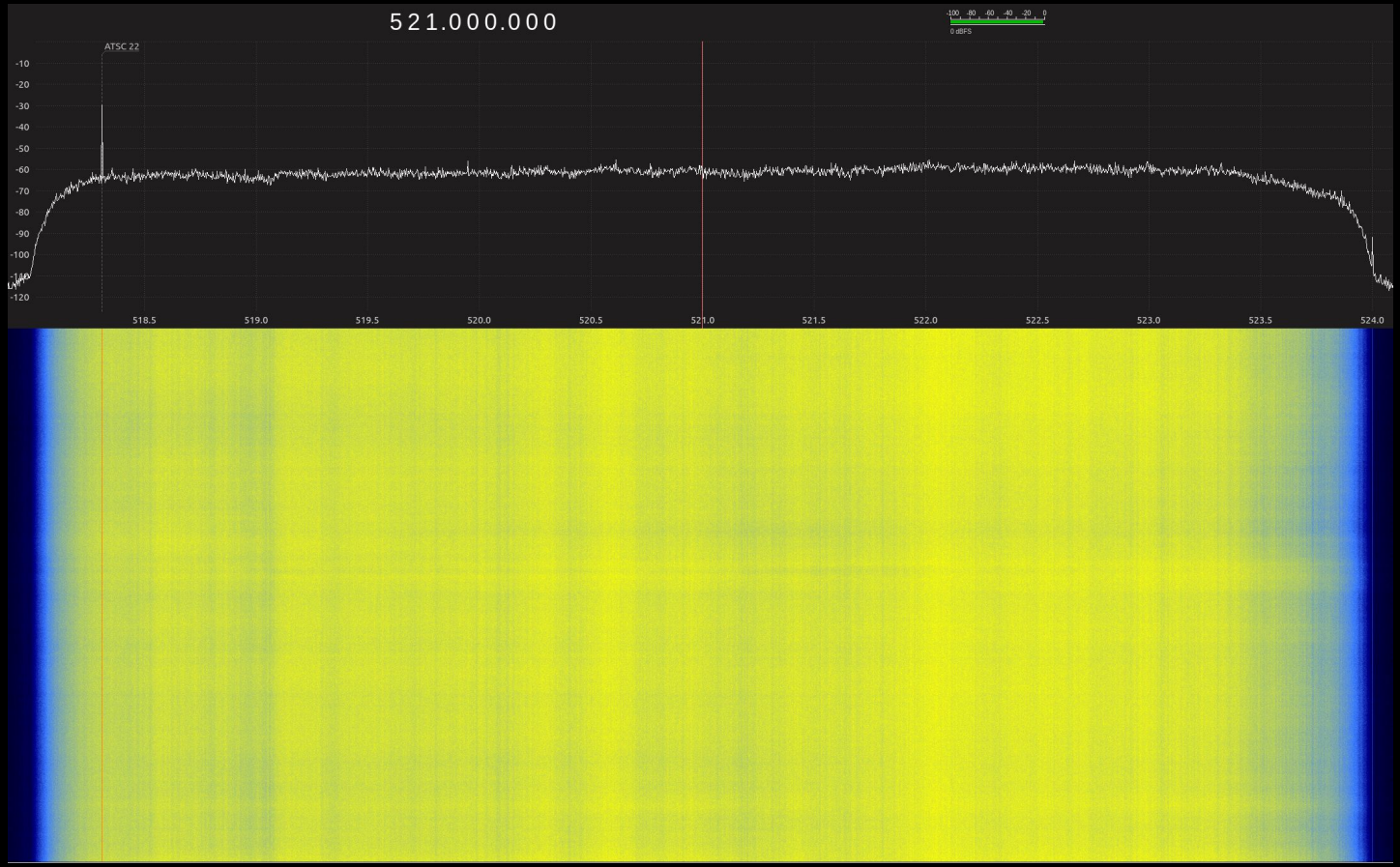

ATSC Pilot Carrier

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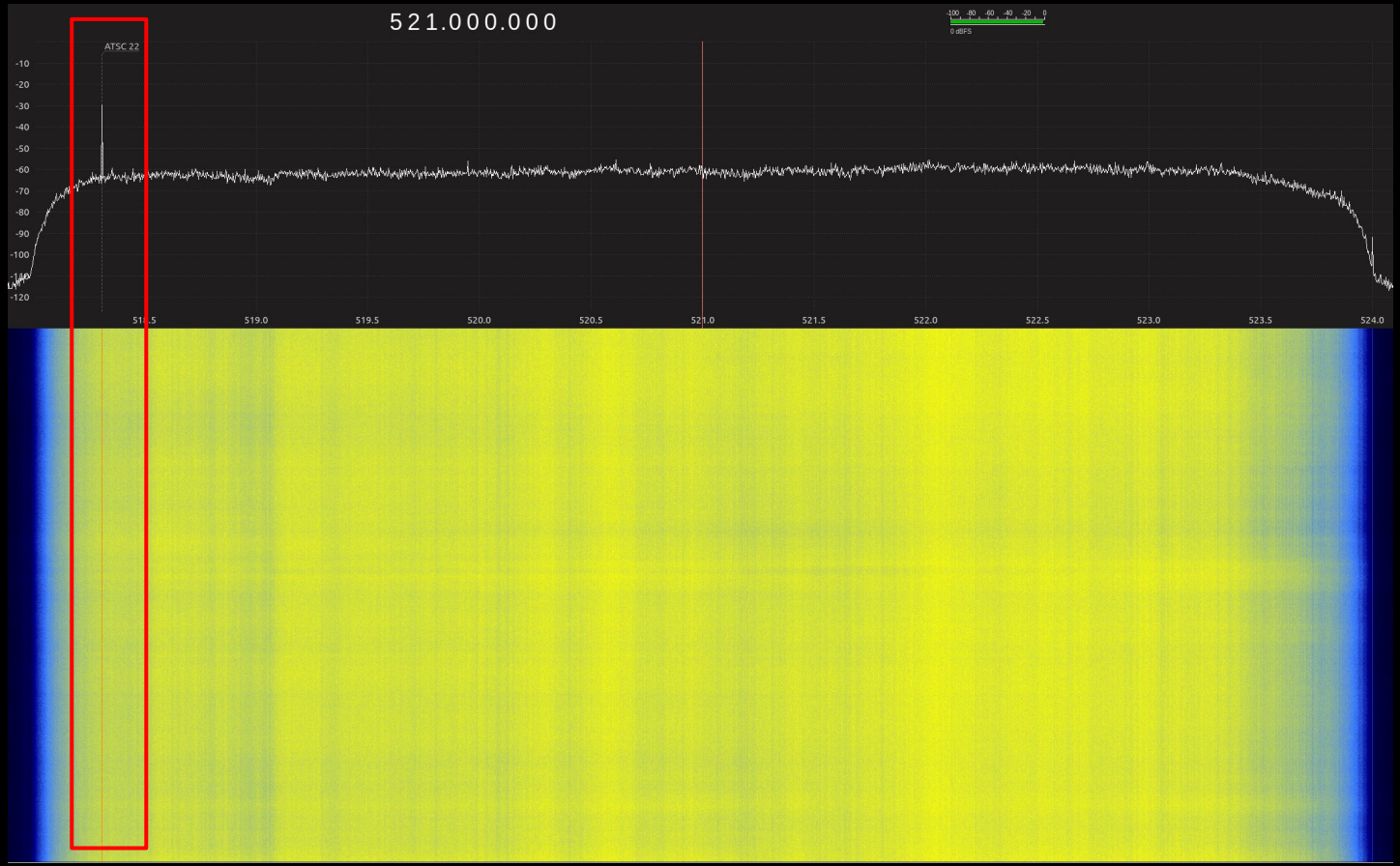

ATSC Passive Radar

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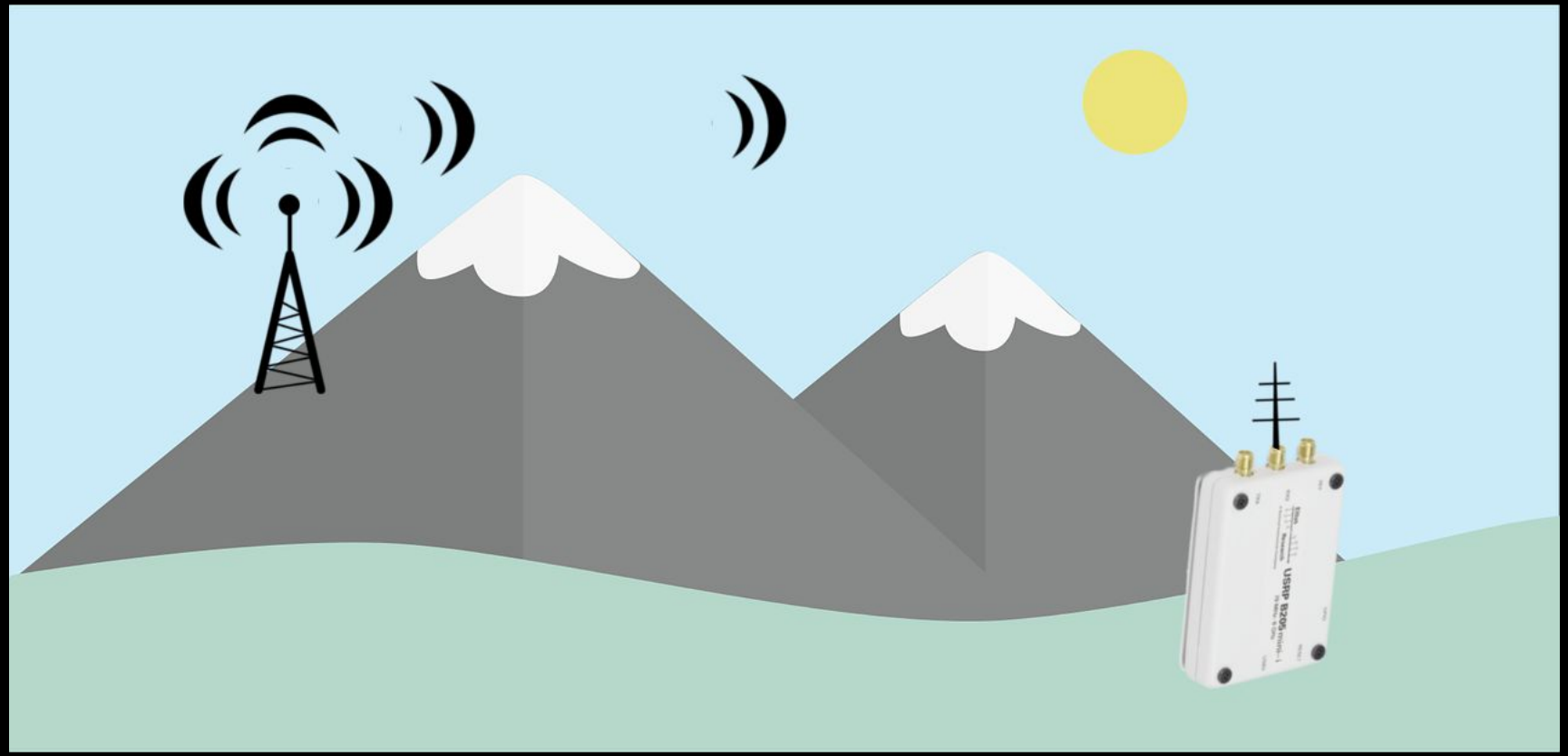

ATSC Passive Radar

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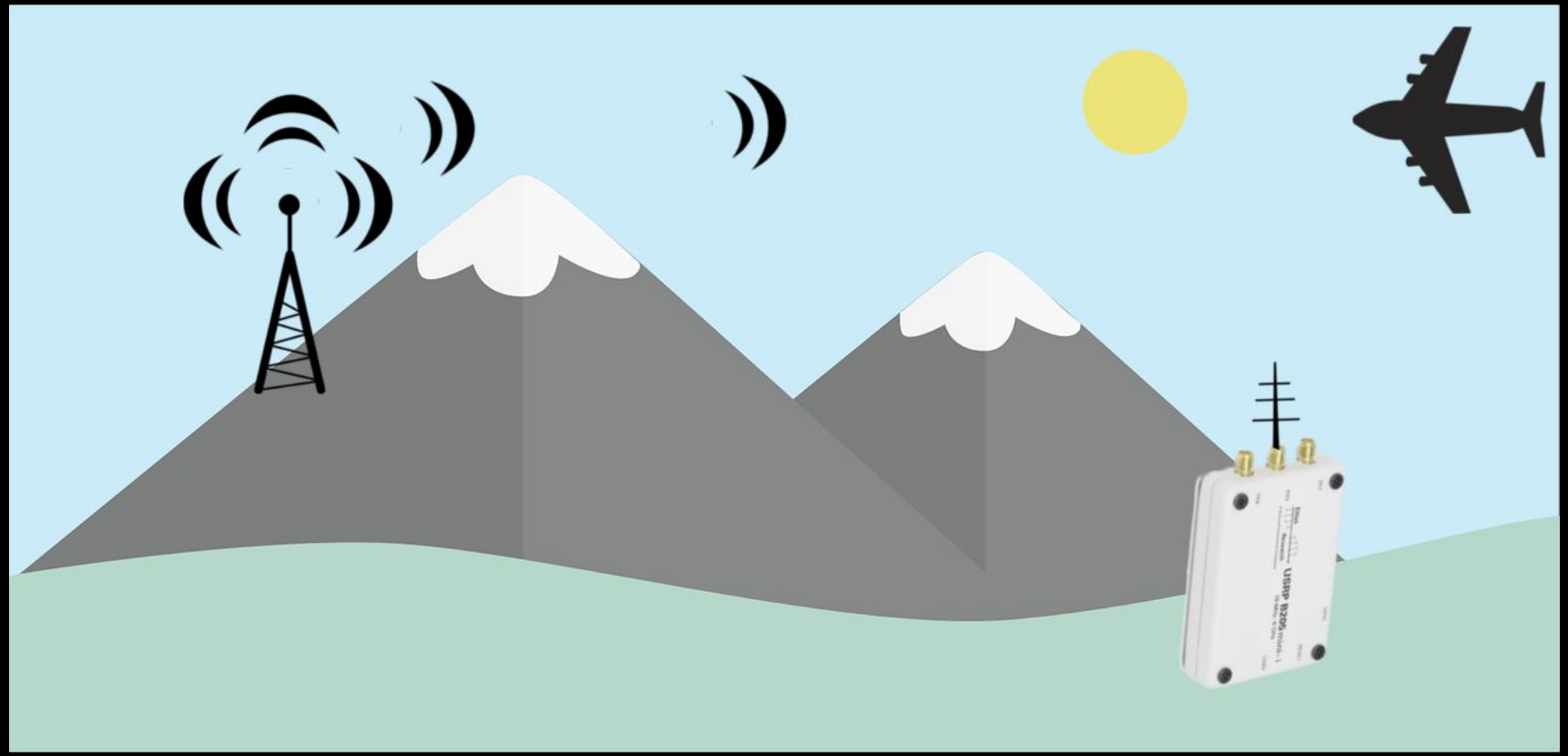

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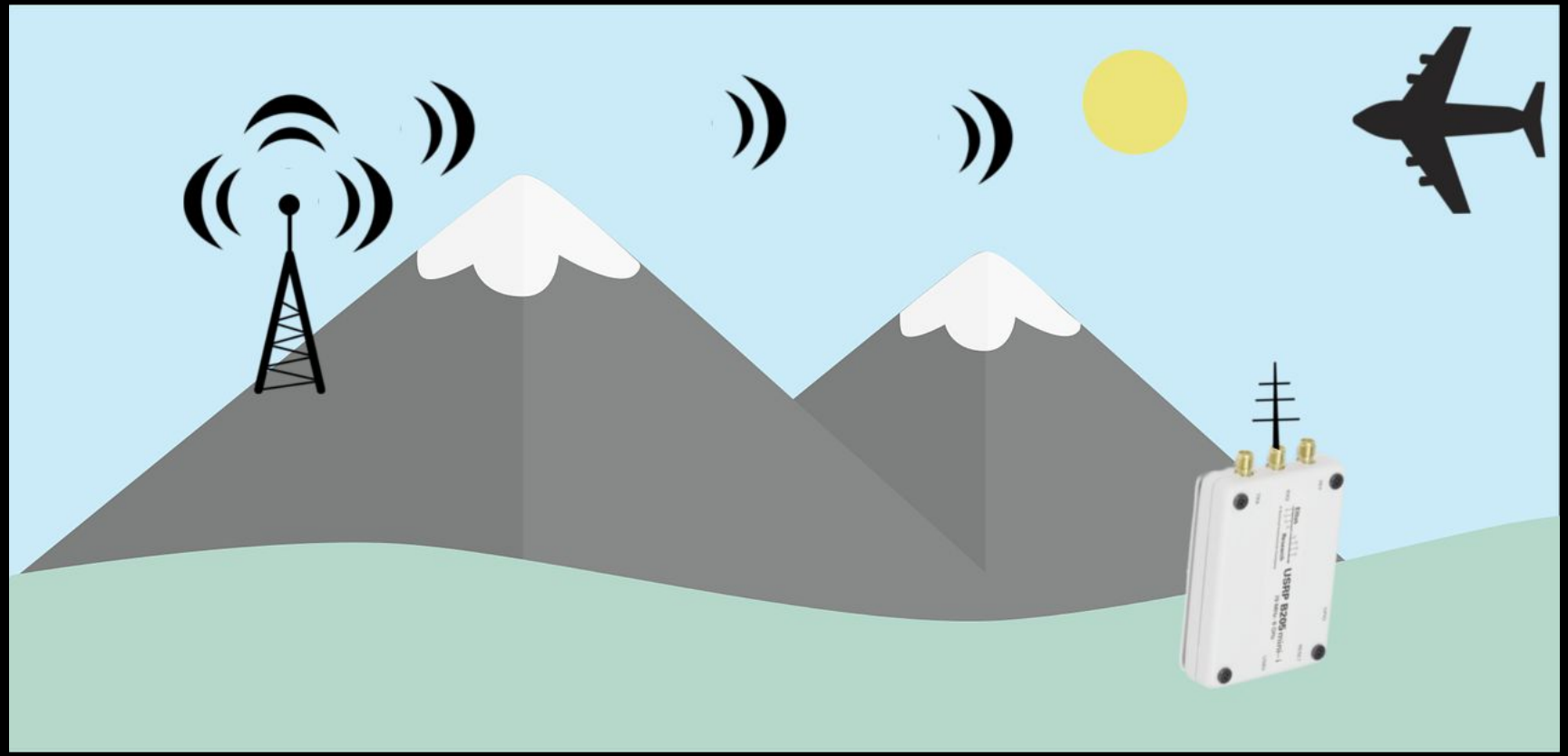

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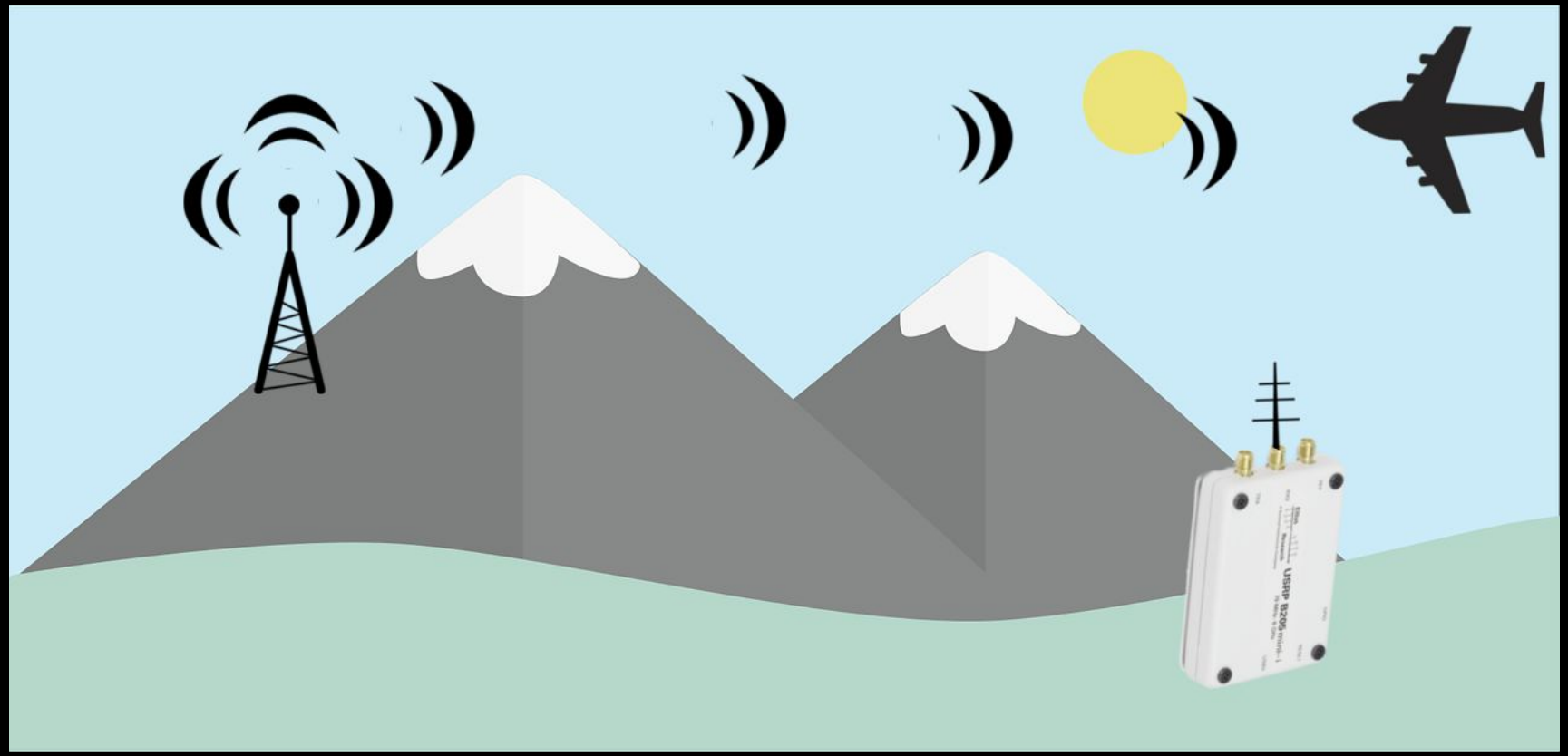

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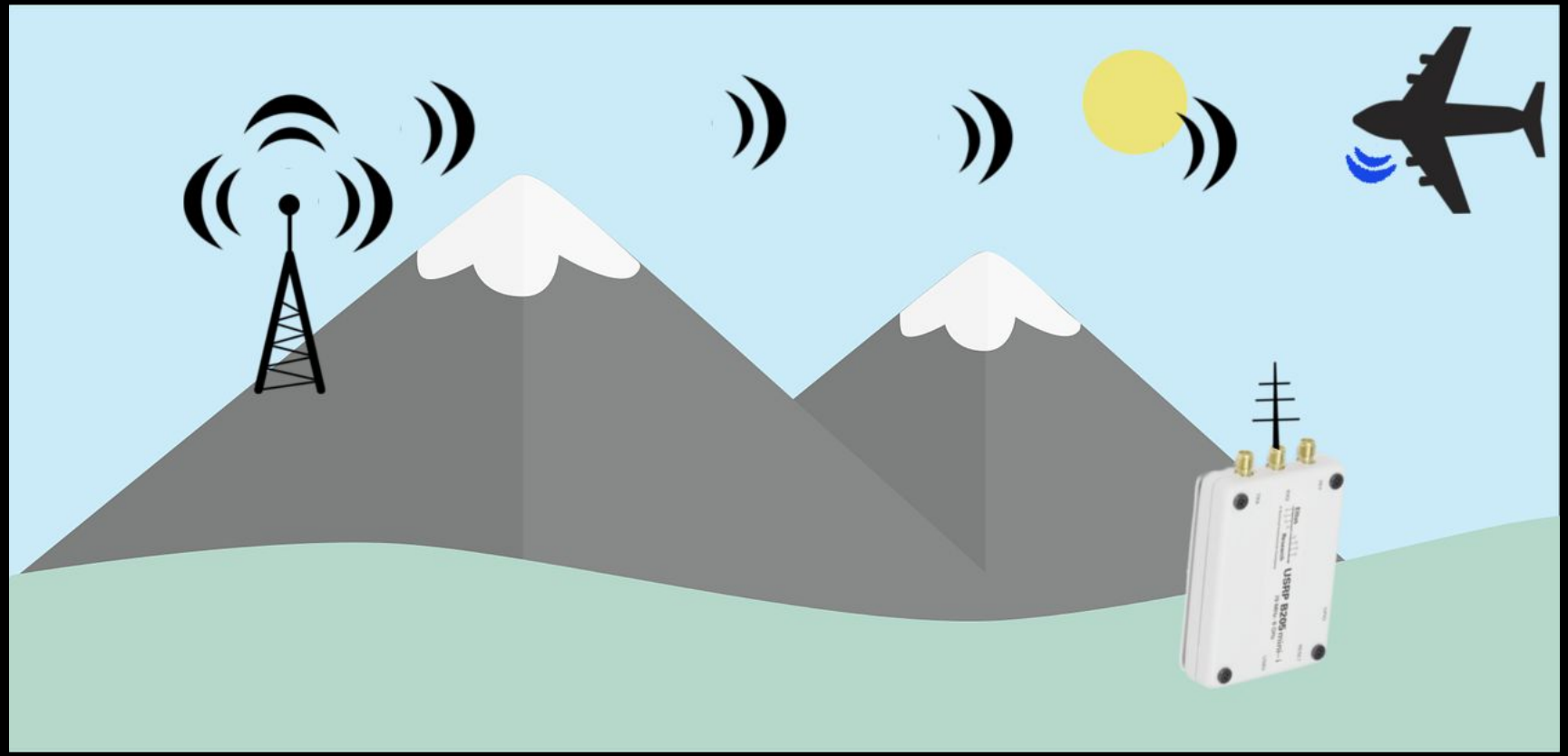

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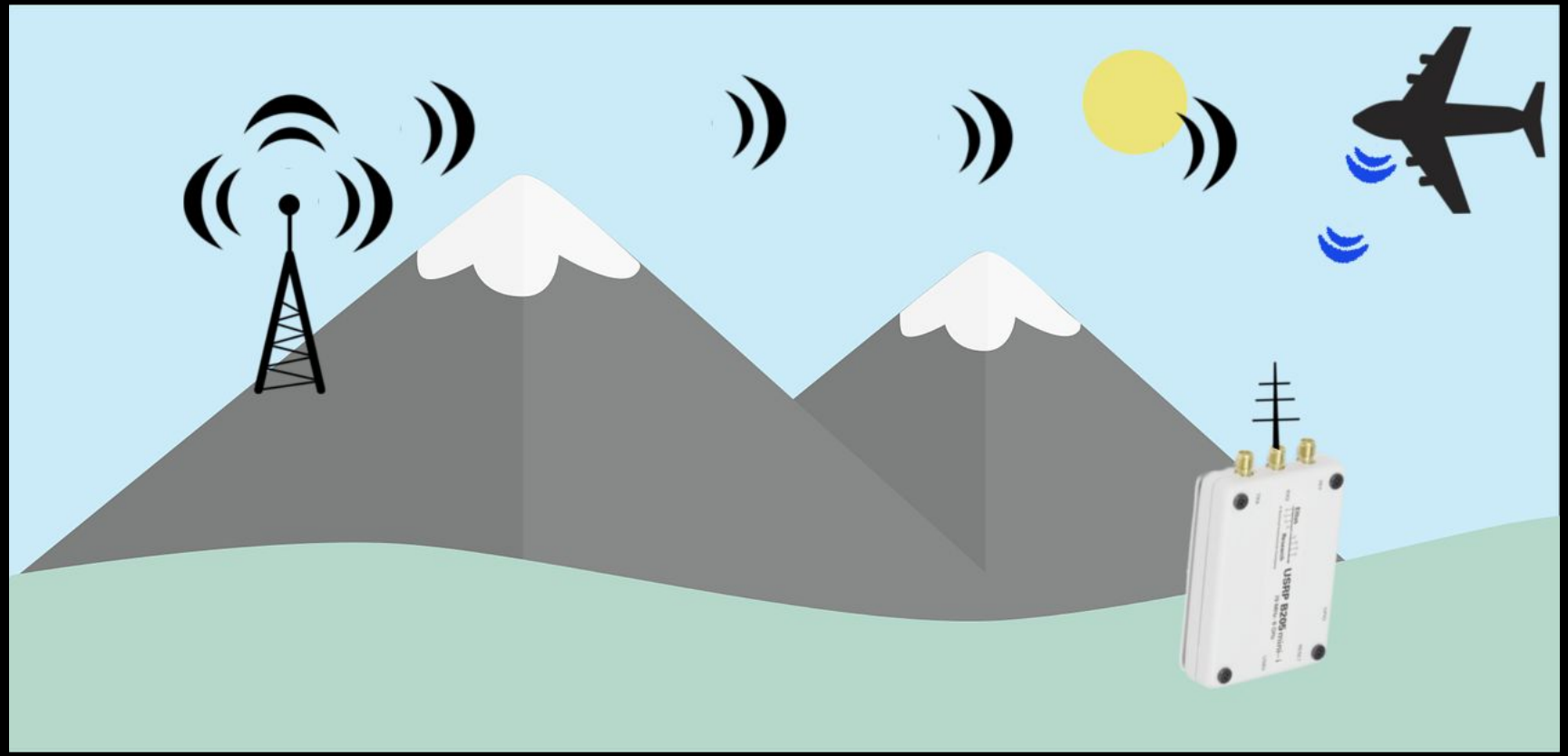

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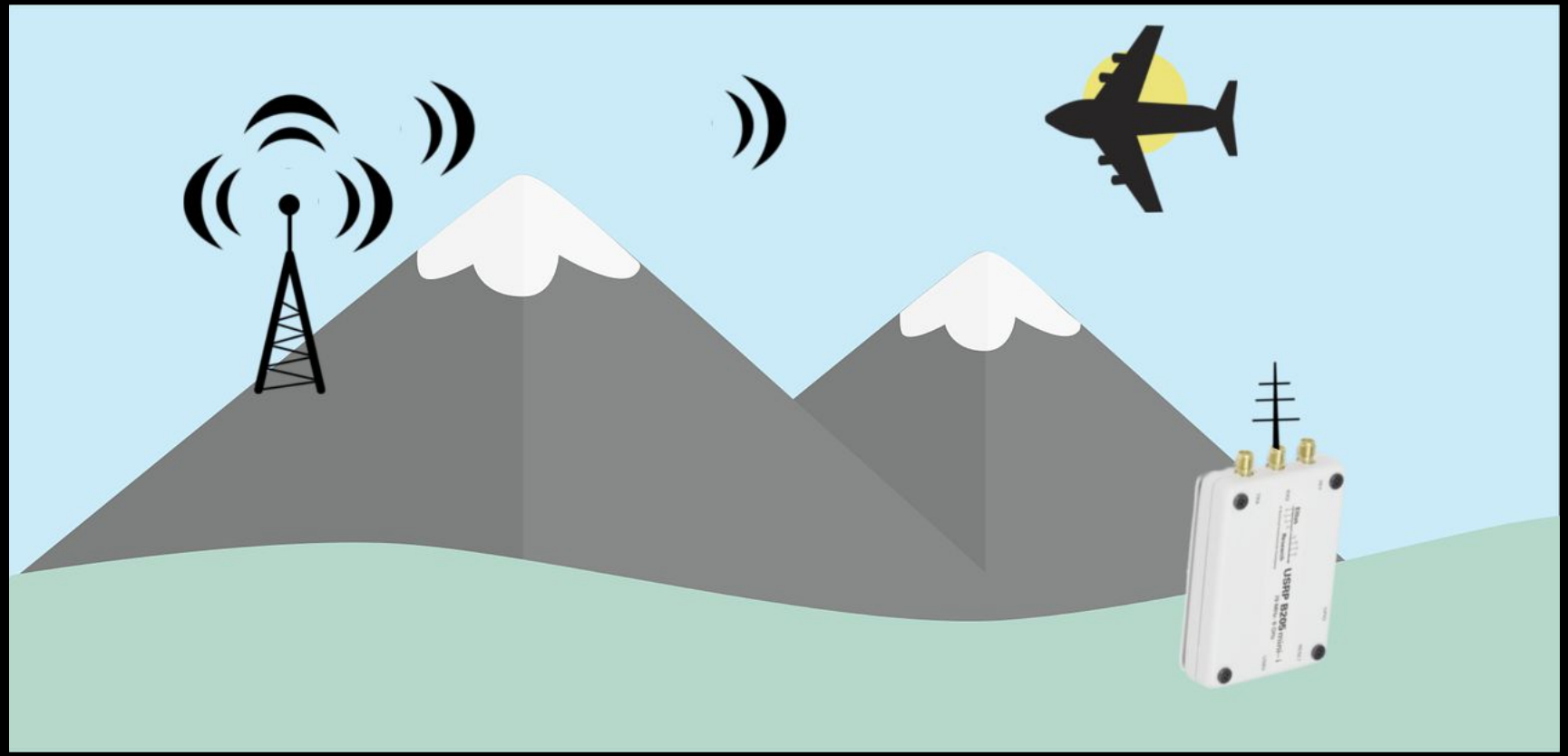

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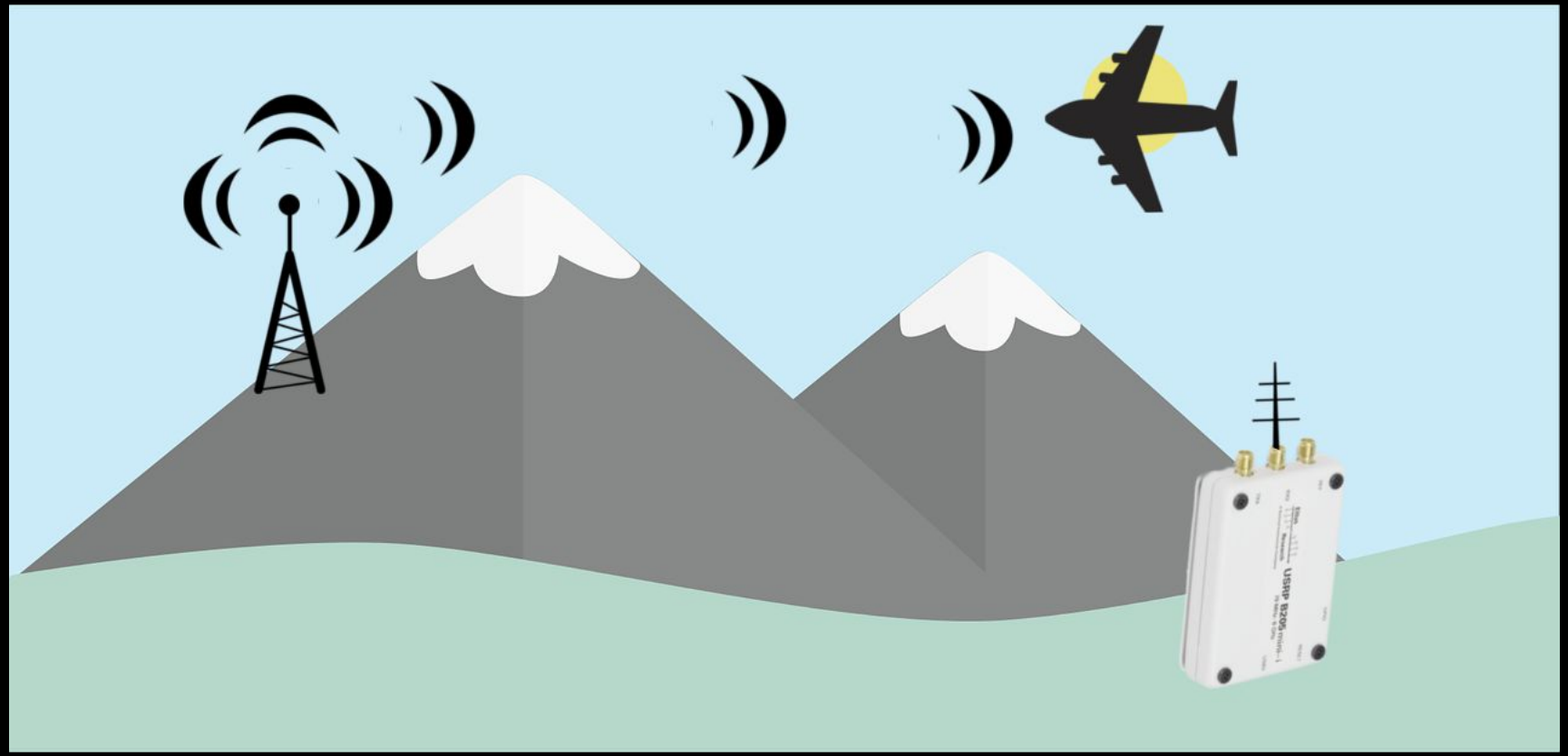

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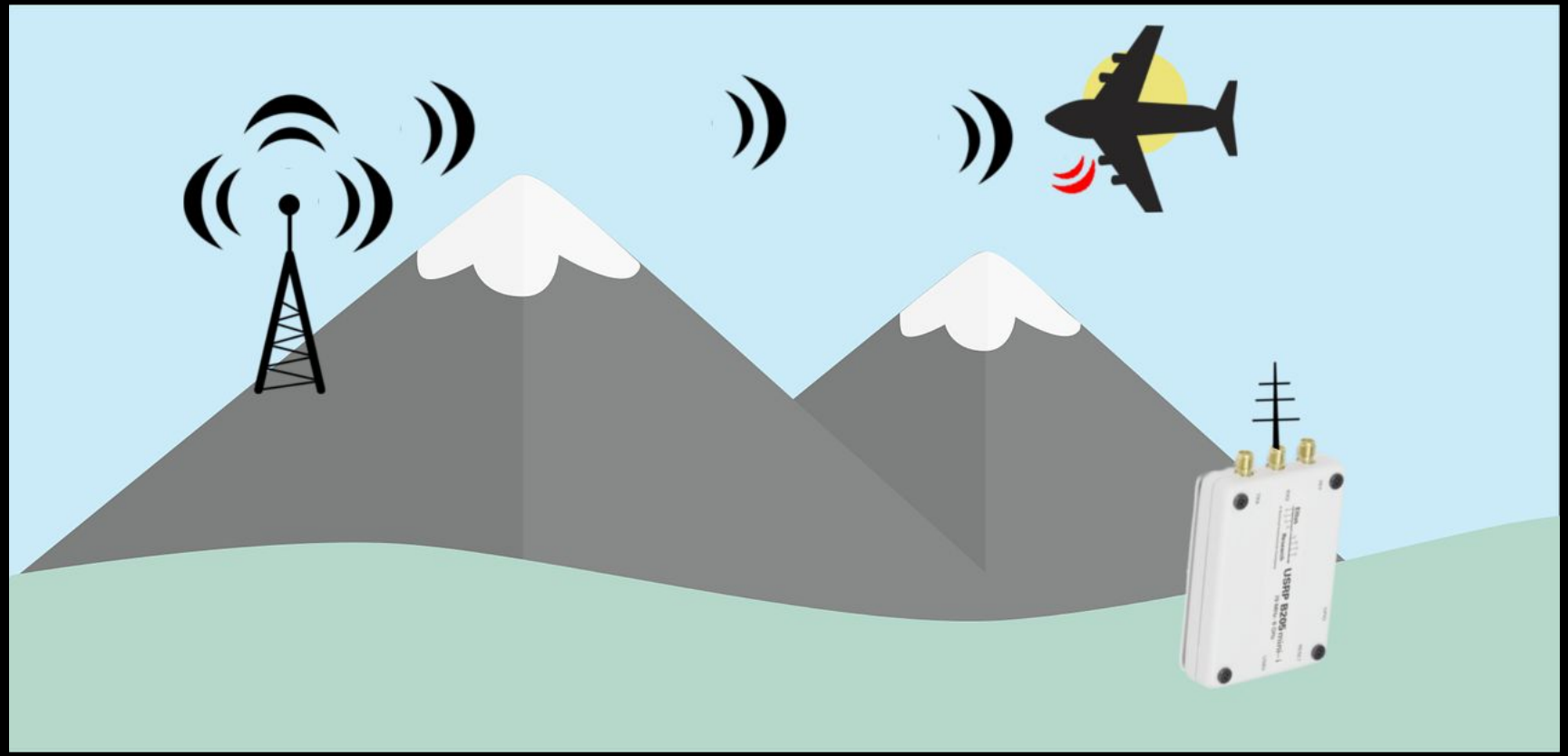

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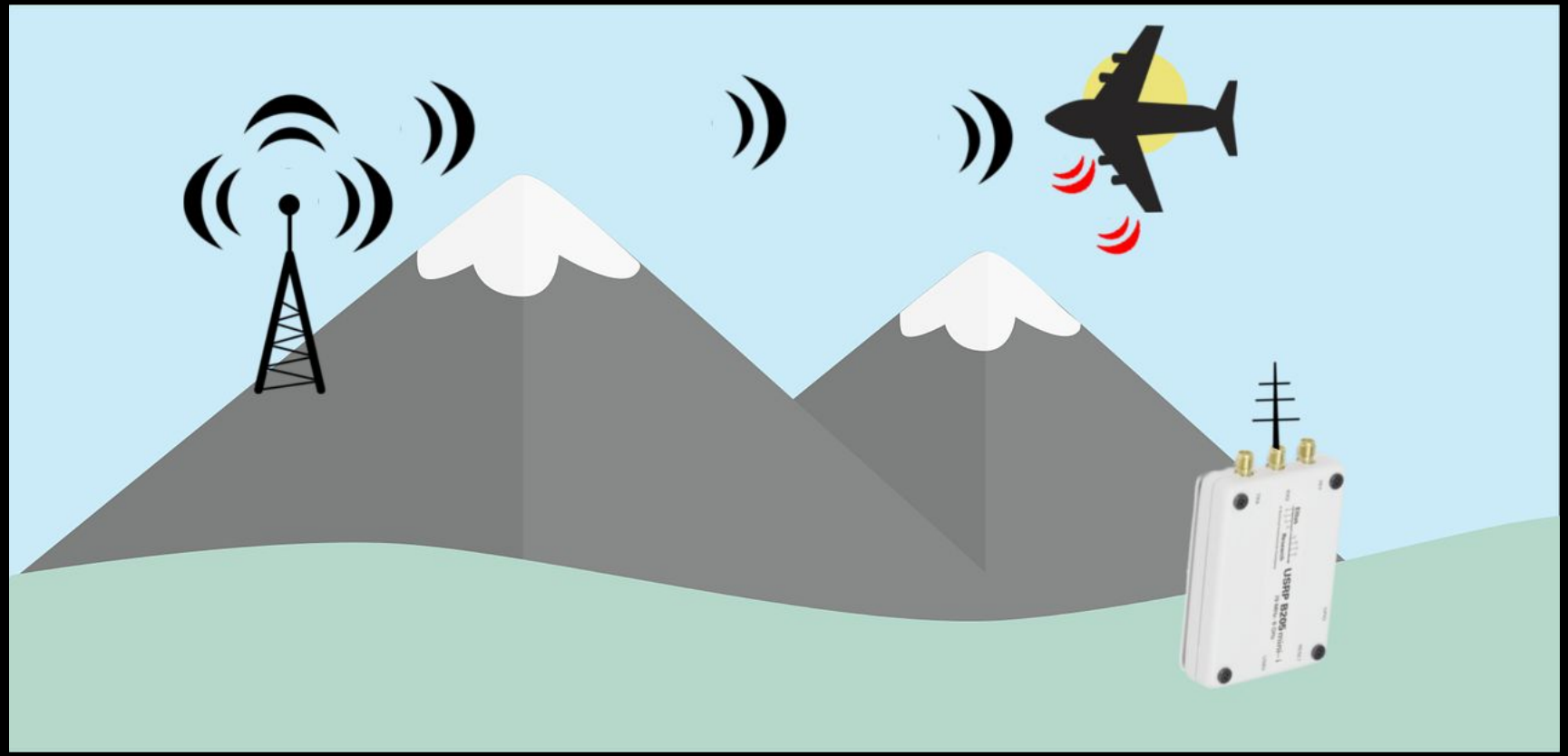

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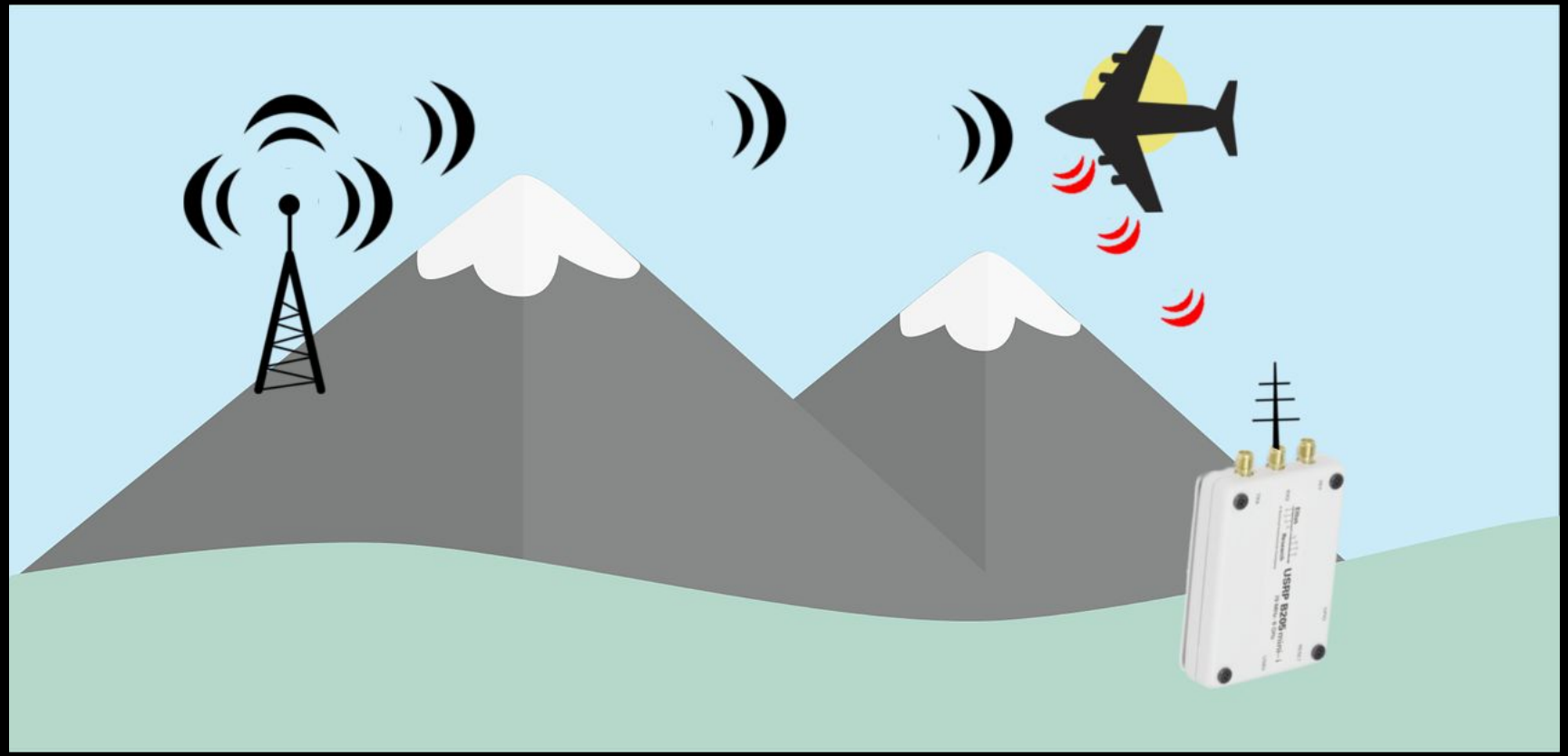

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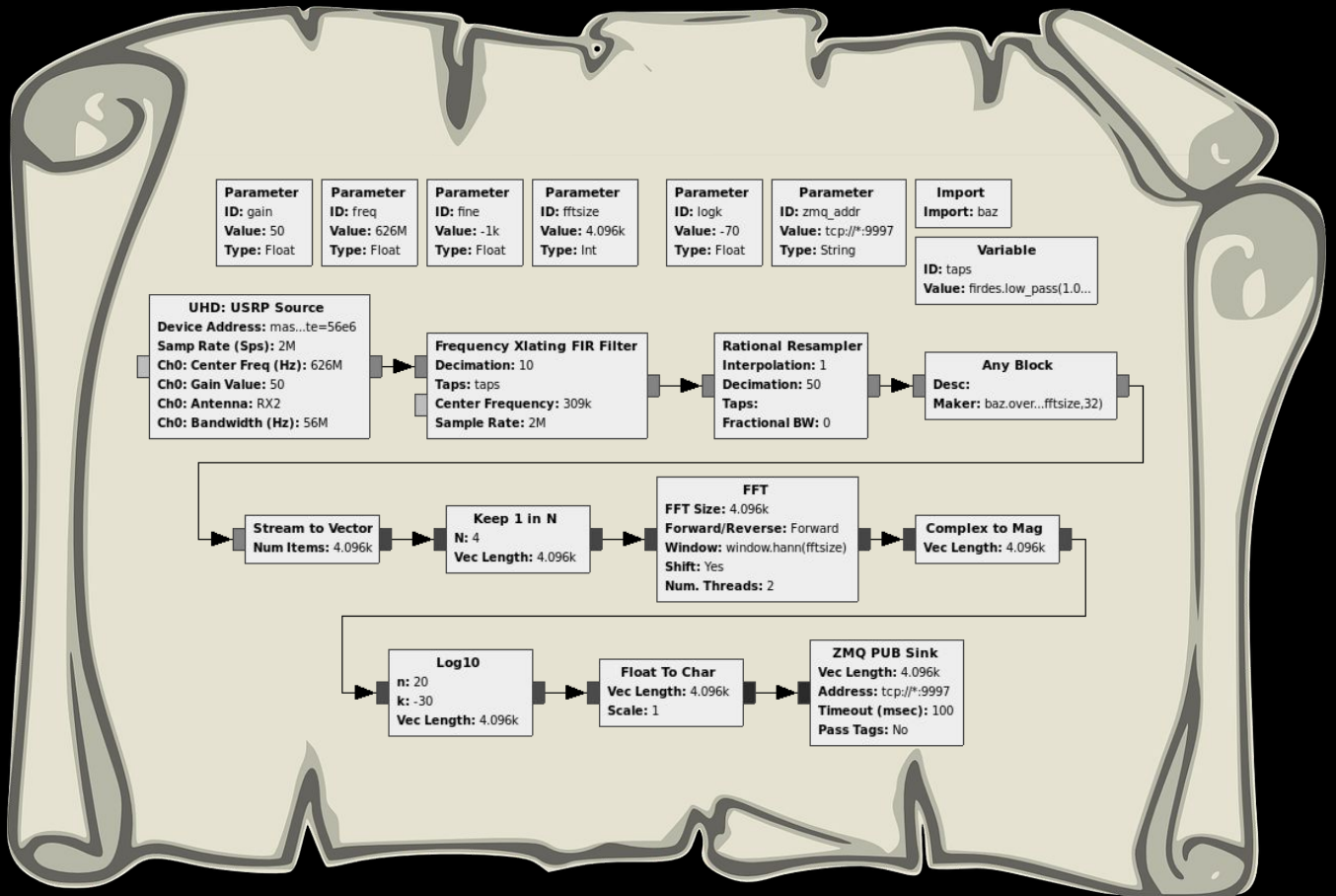

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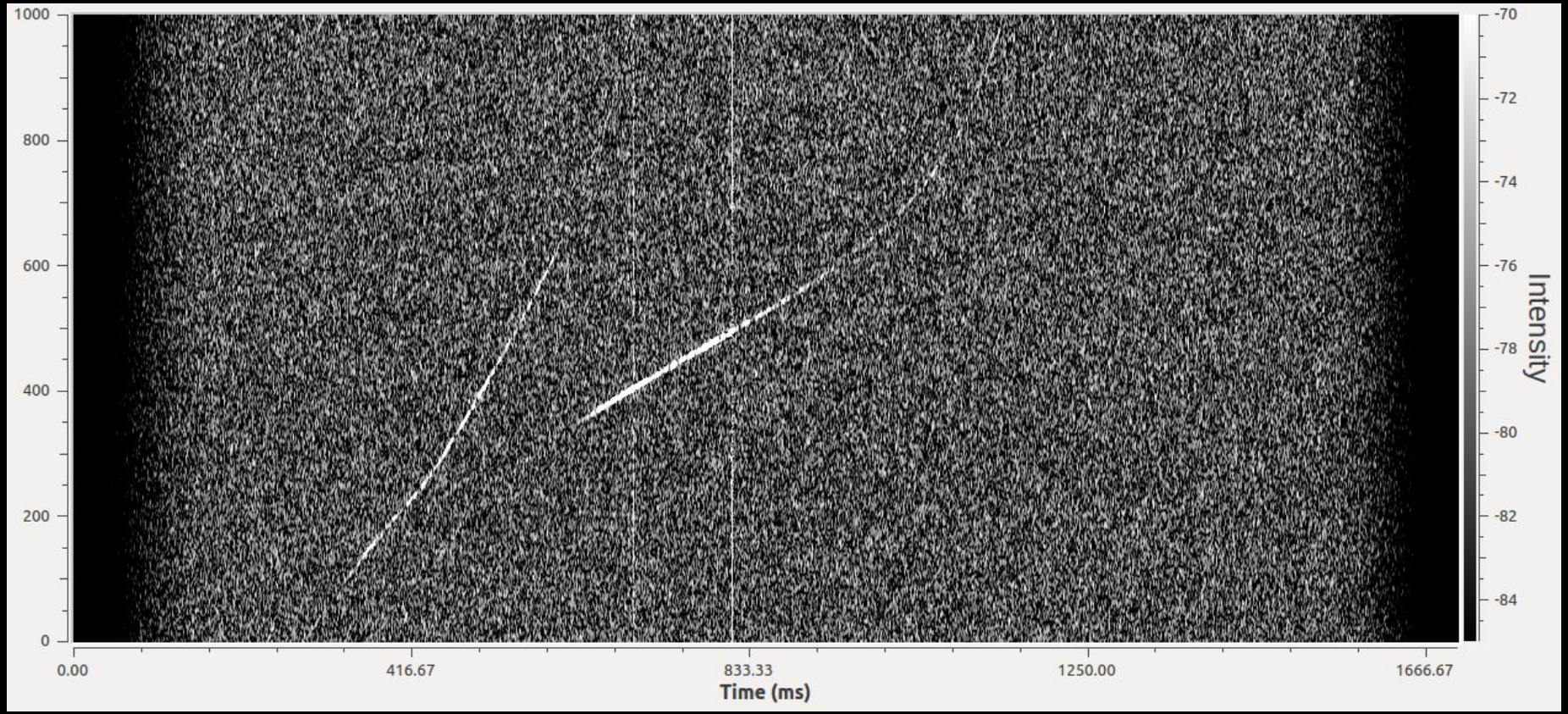

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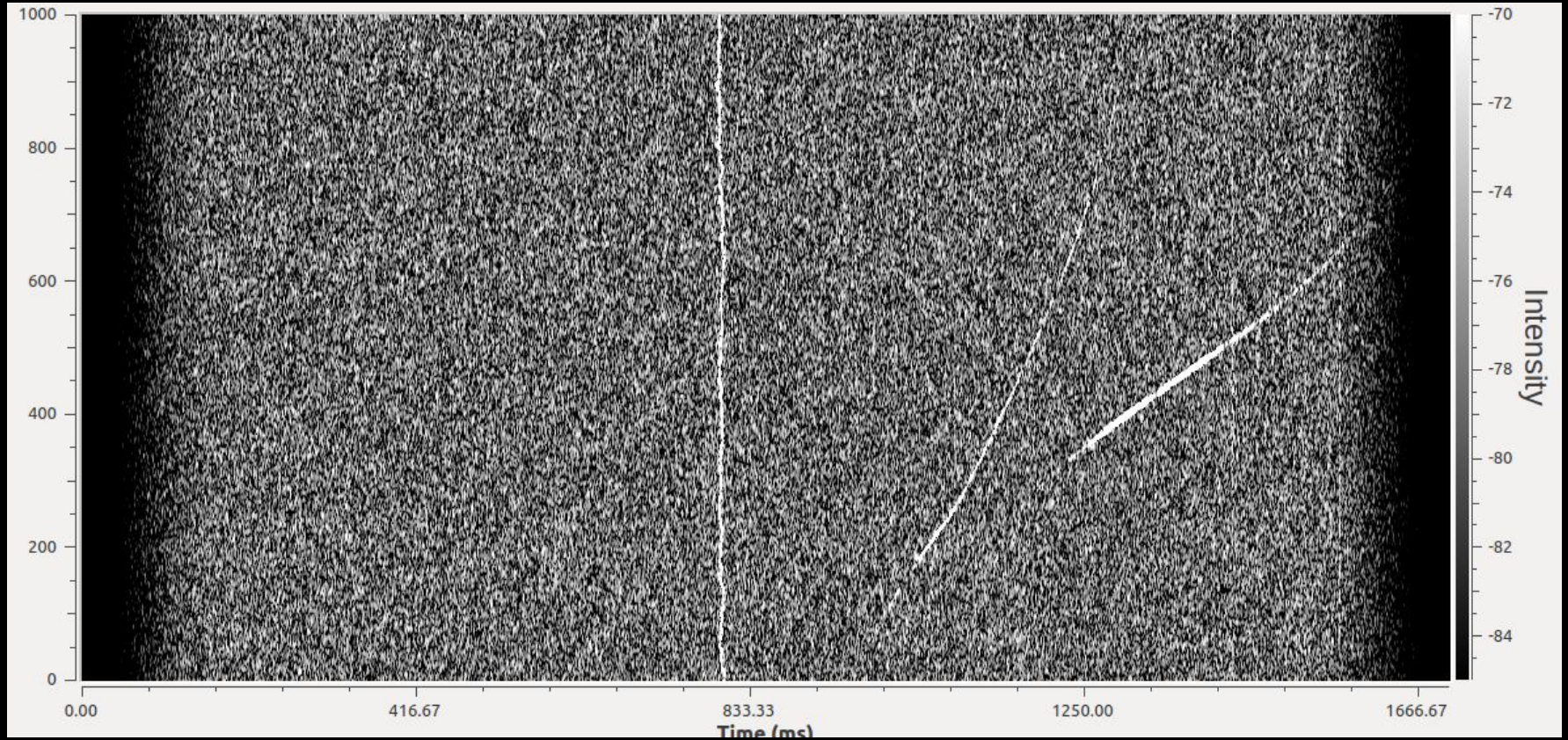

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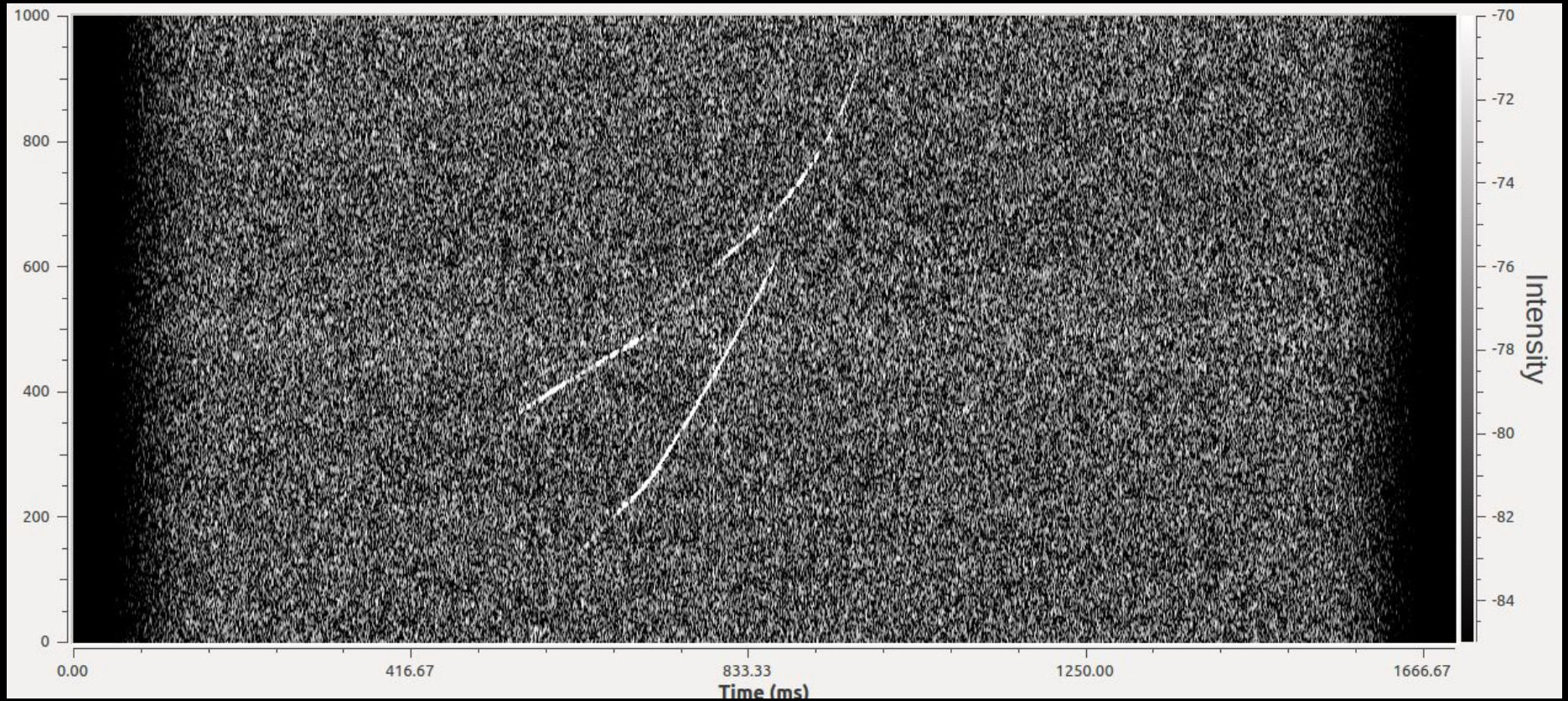

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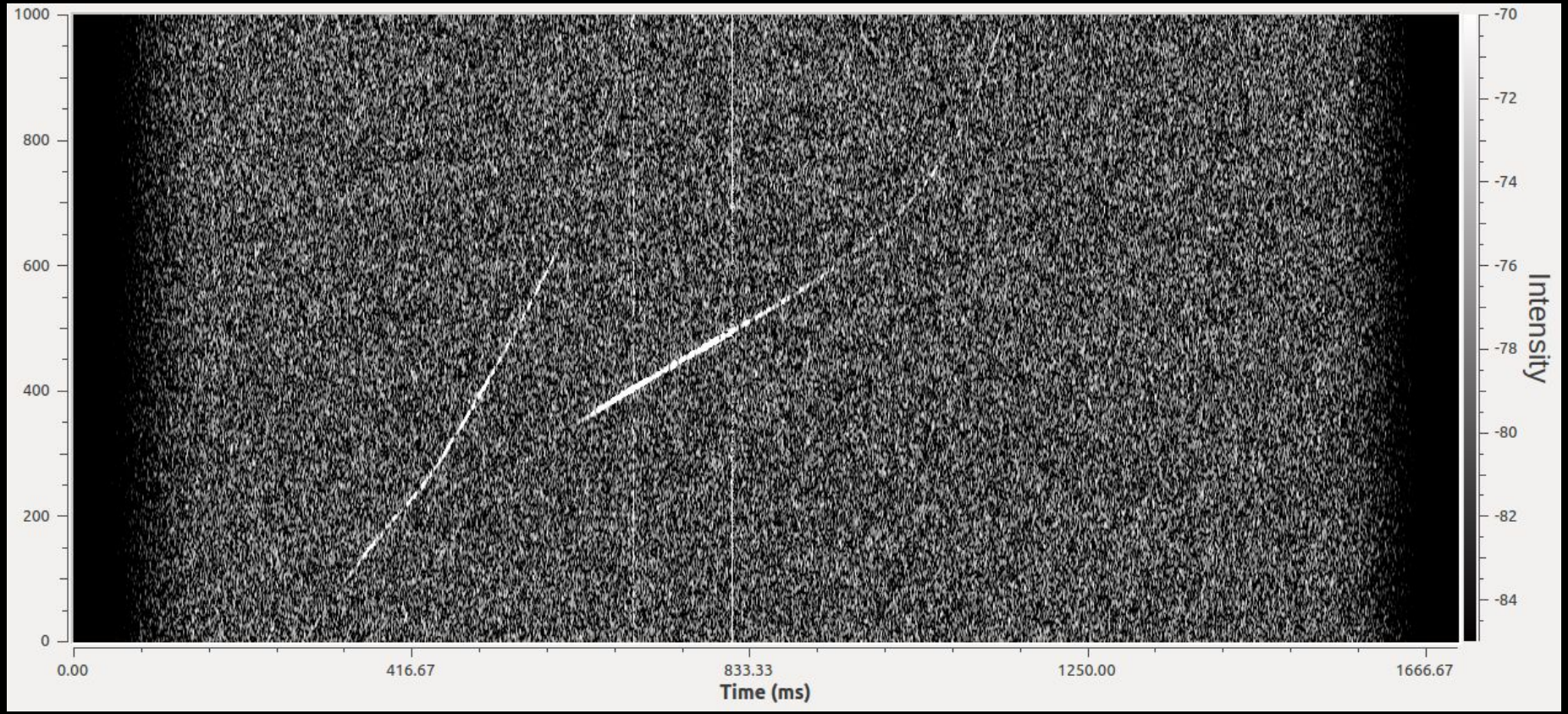

ATSC Passive Radar - Planes

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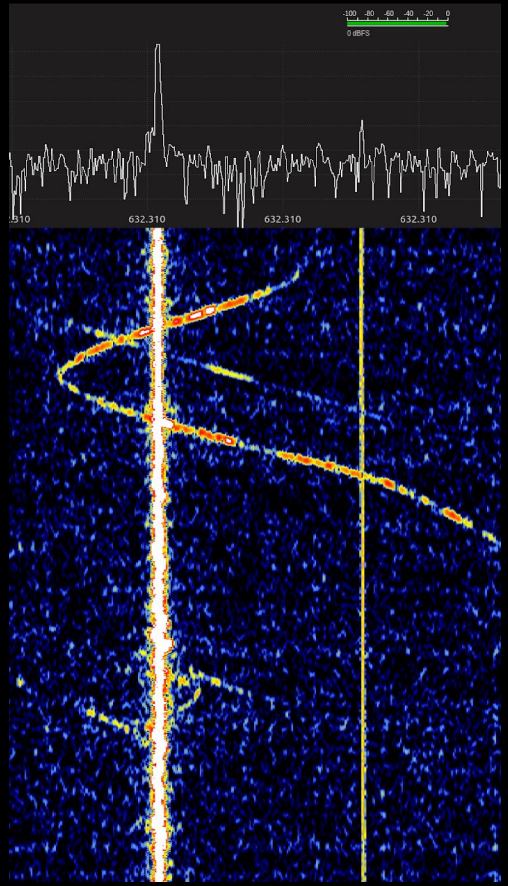

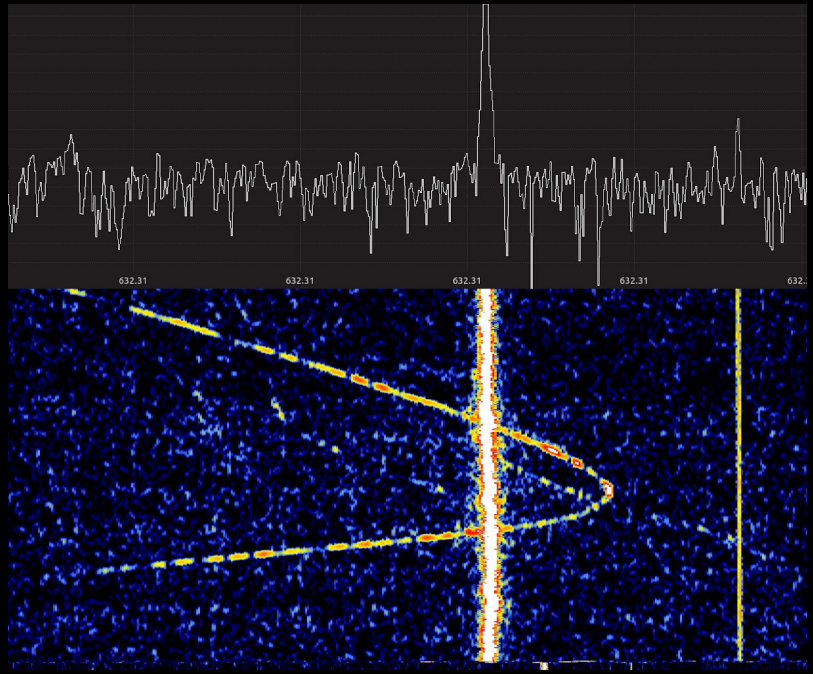

ATSC Passive Radar - Planes

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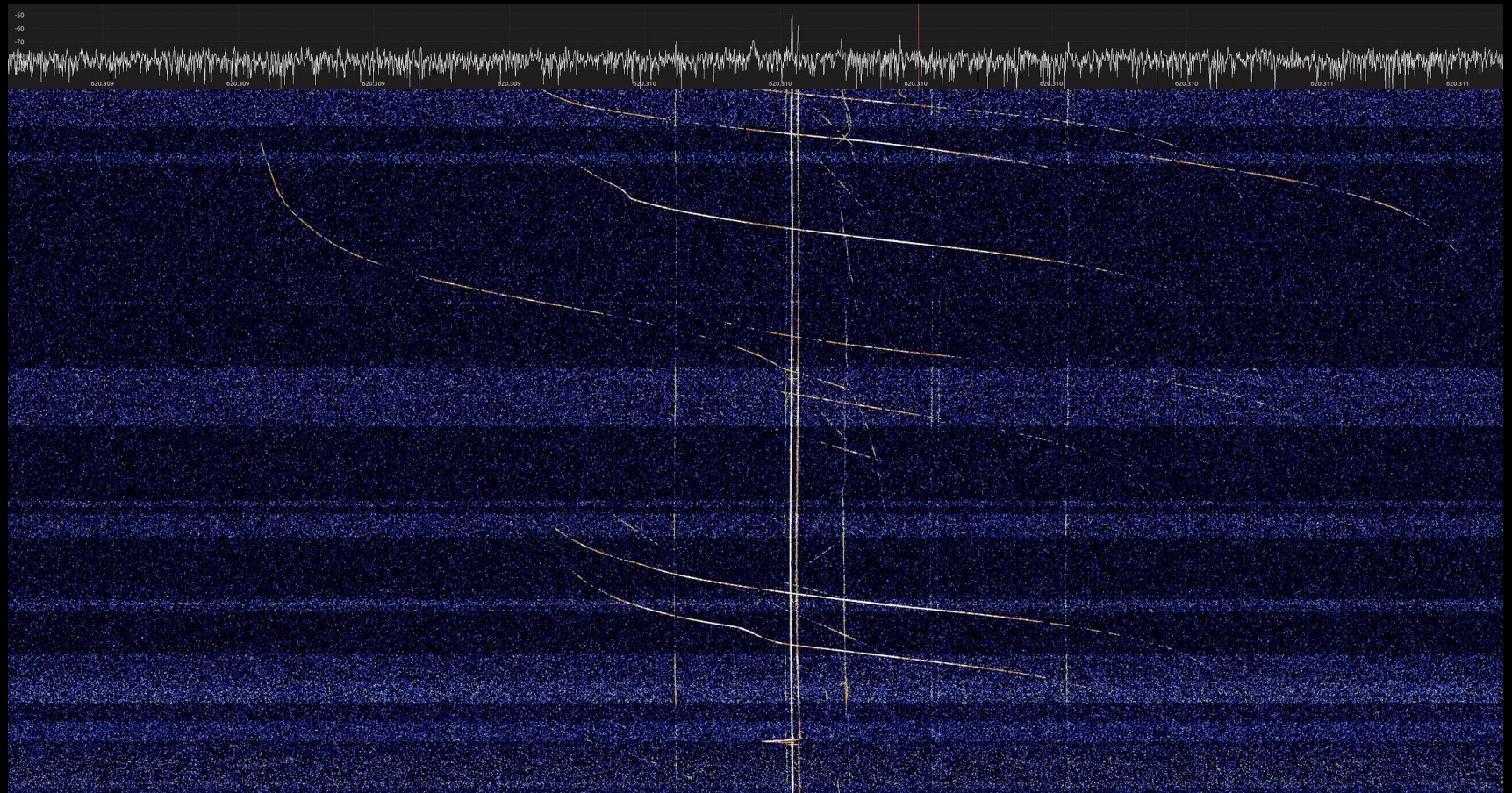

ATSC Passive Radar - Planes

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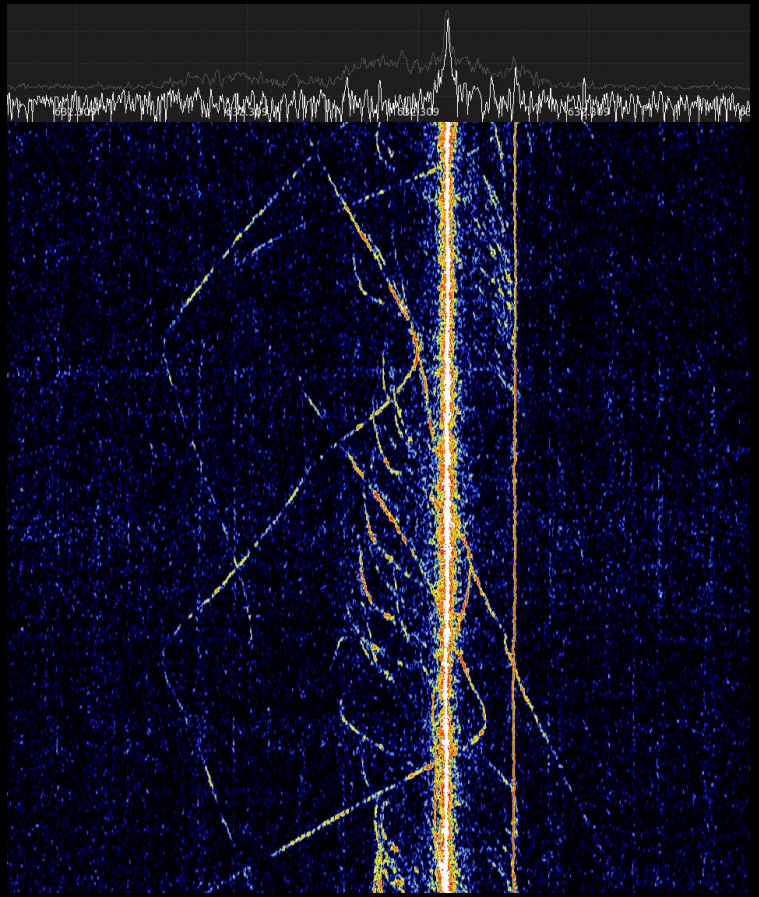

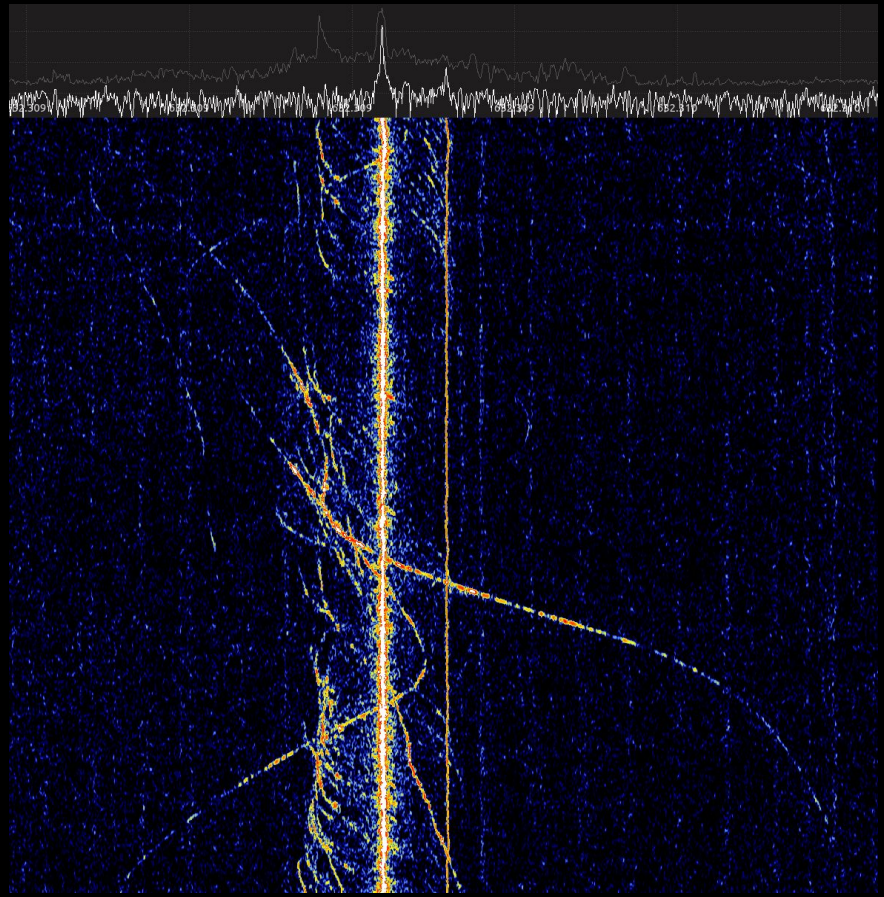

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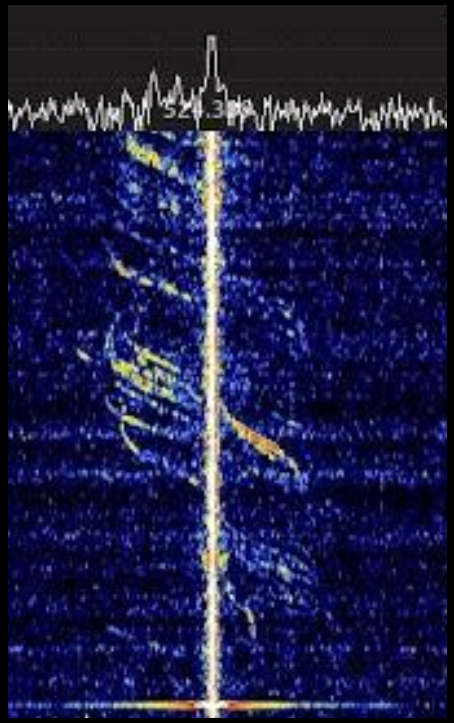

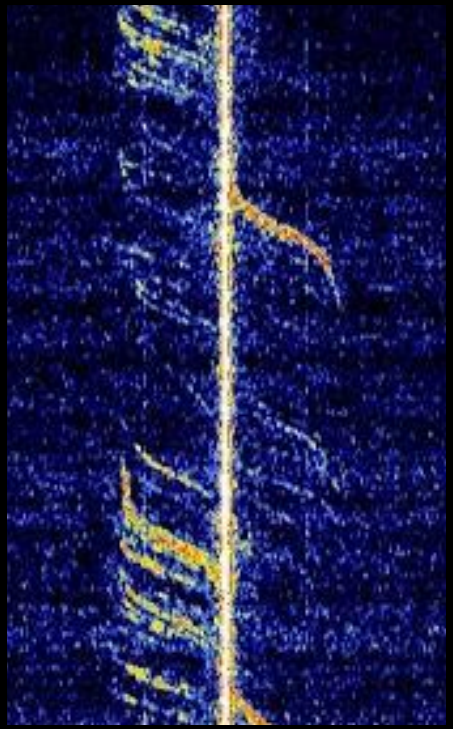

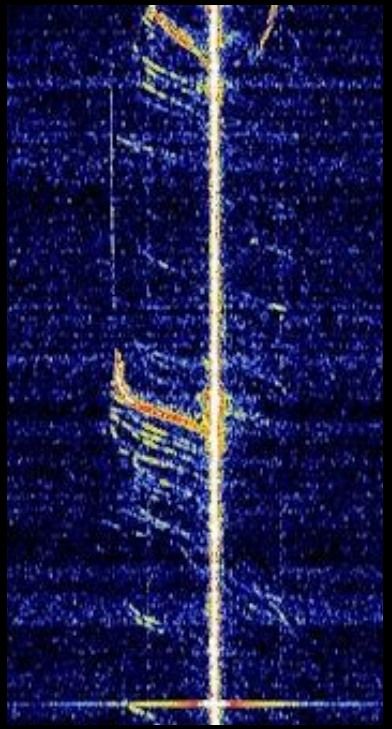

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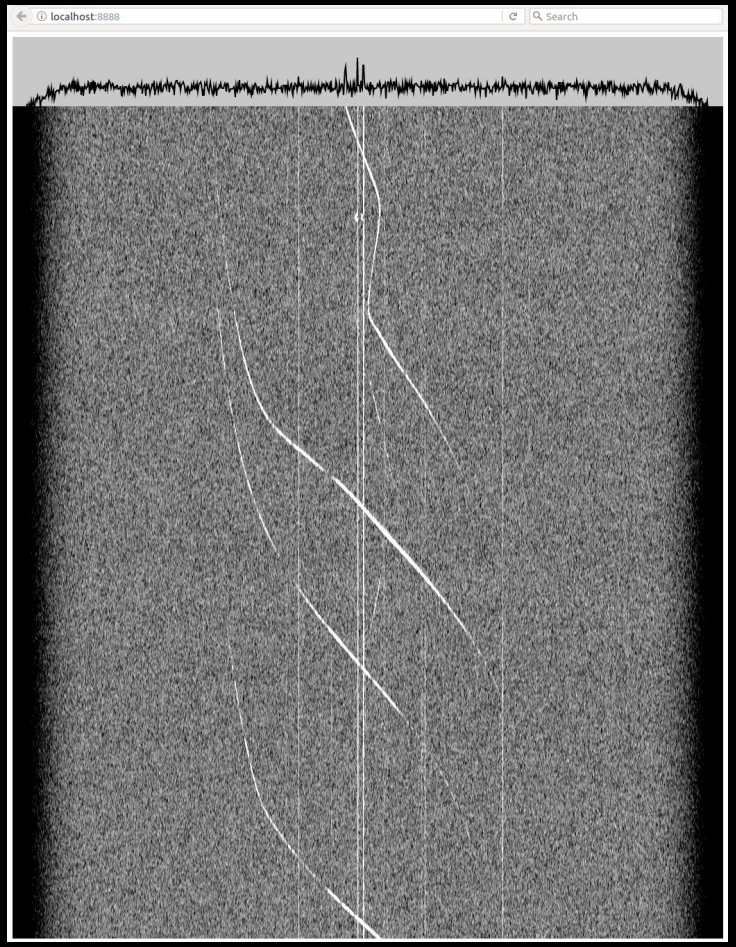

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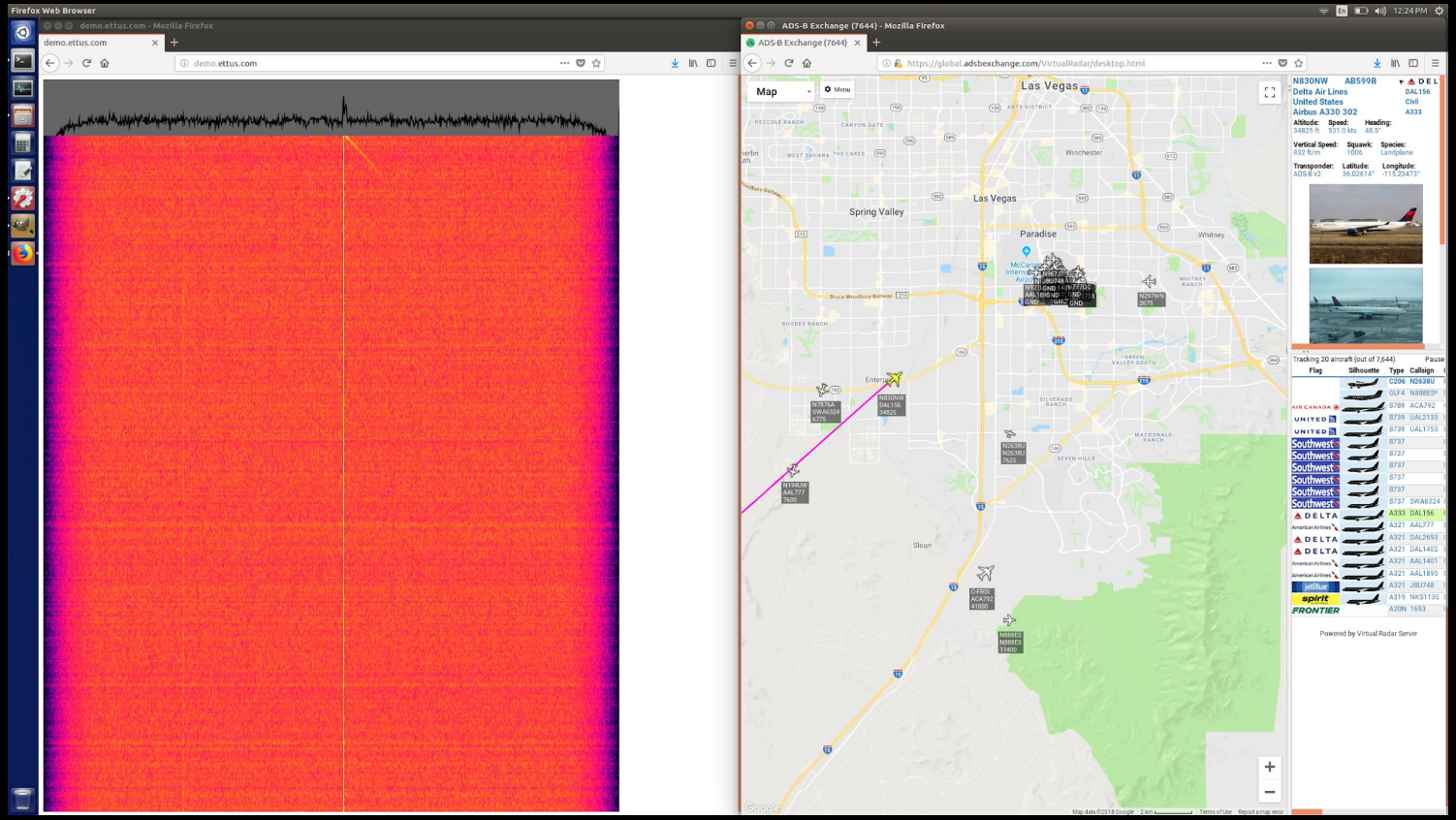

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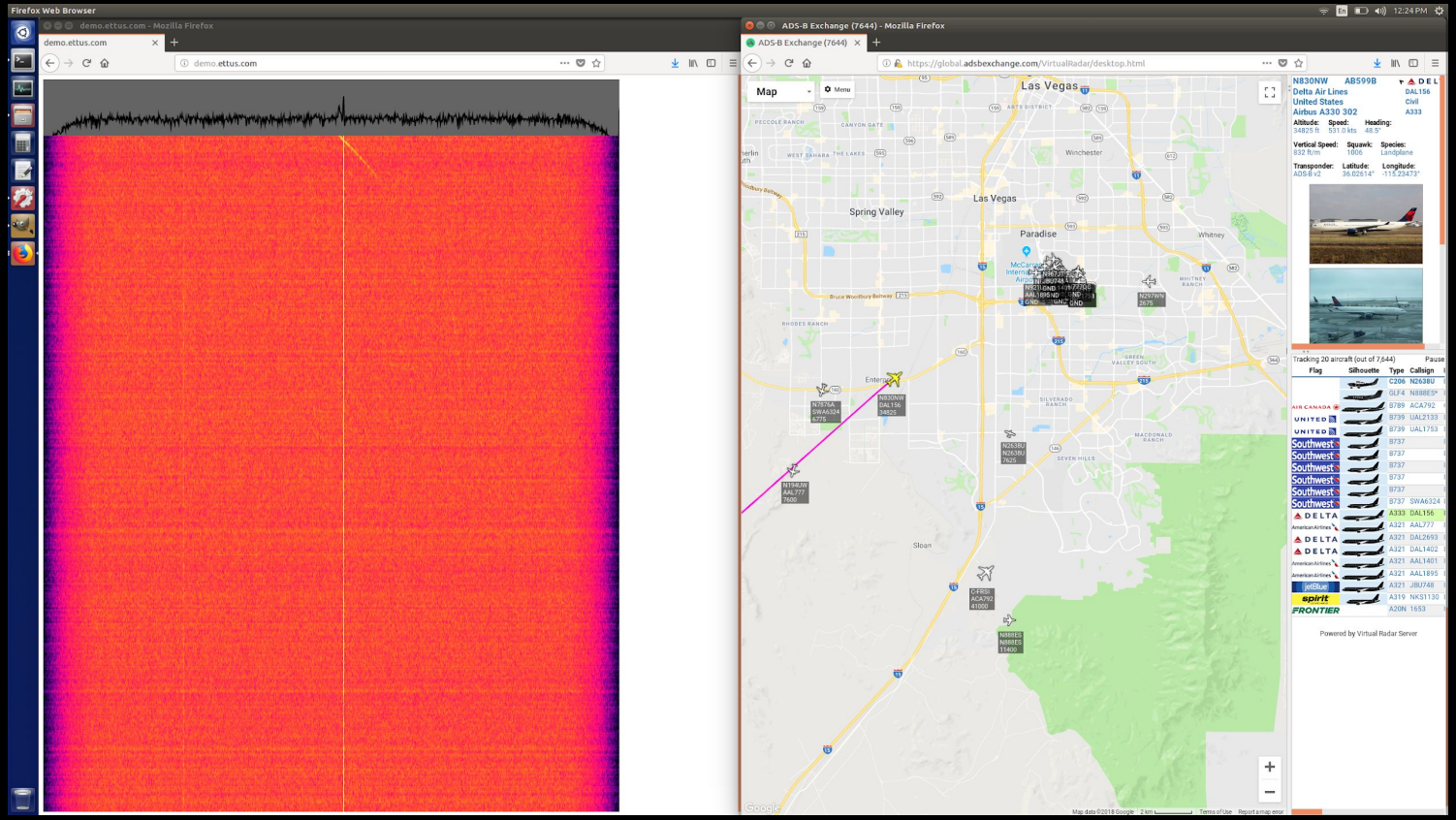

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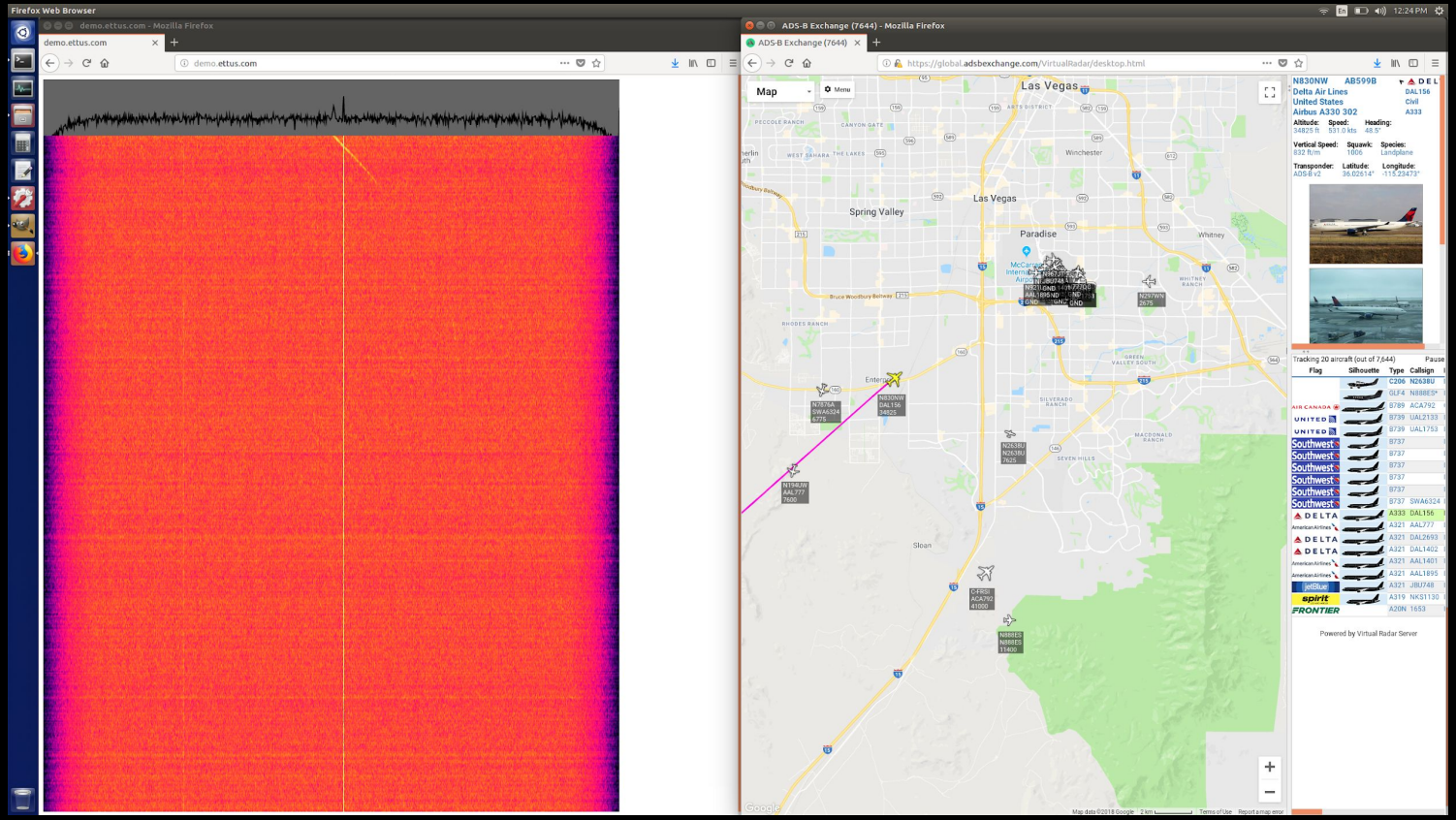

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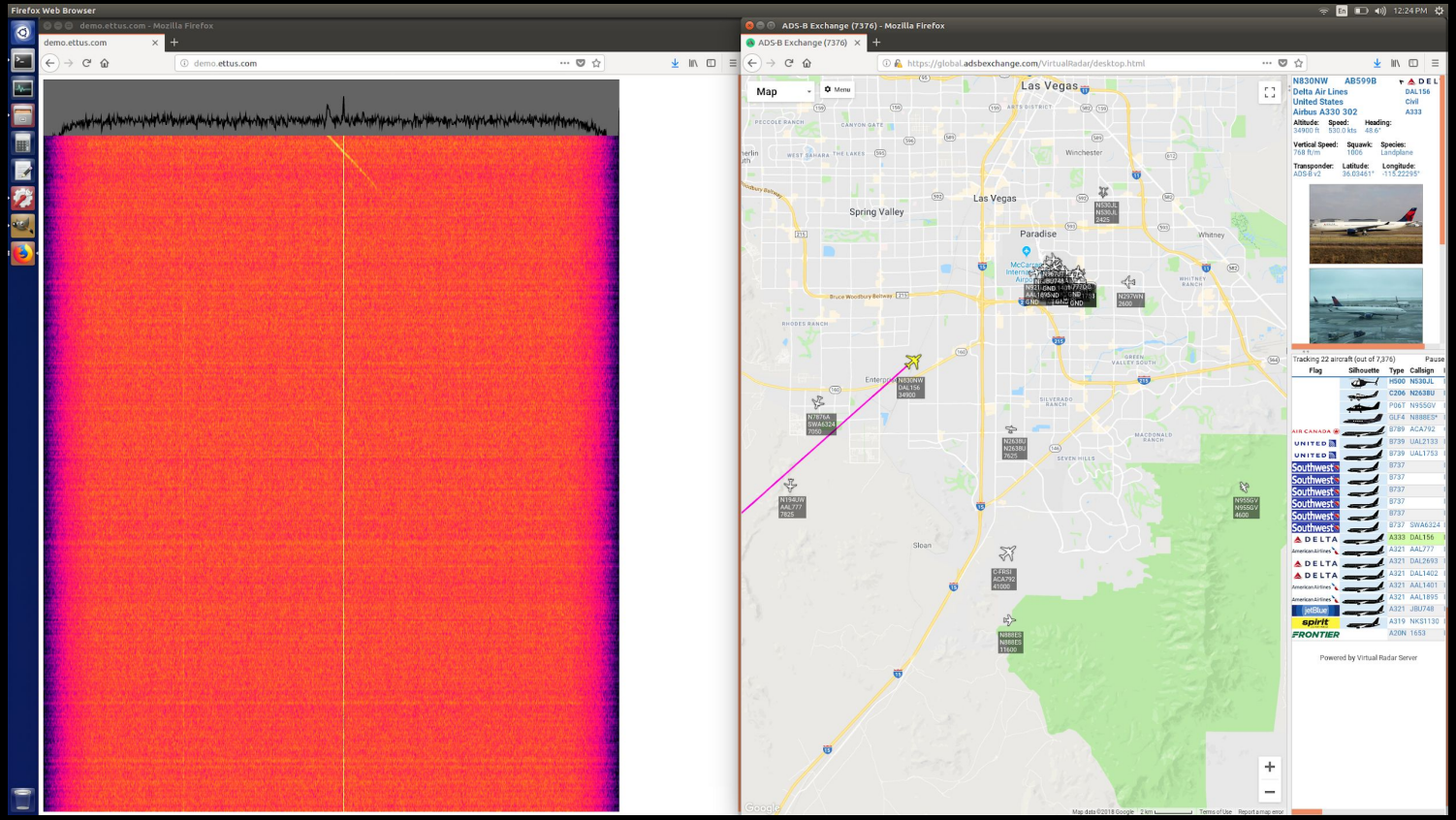

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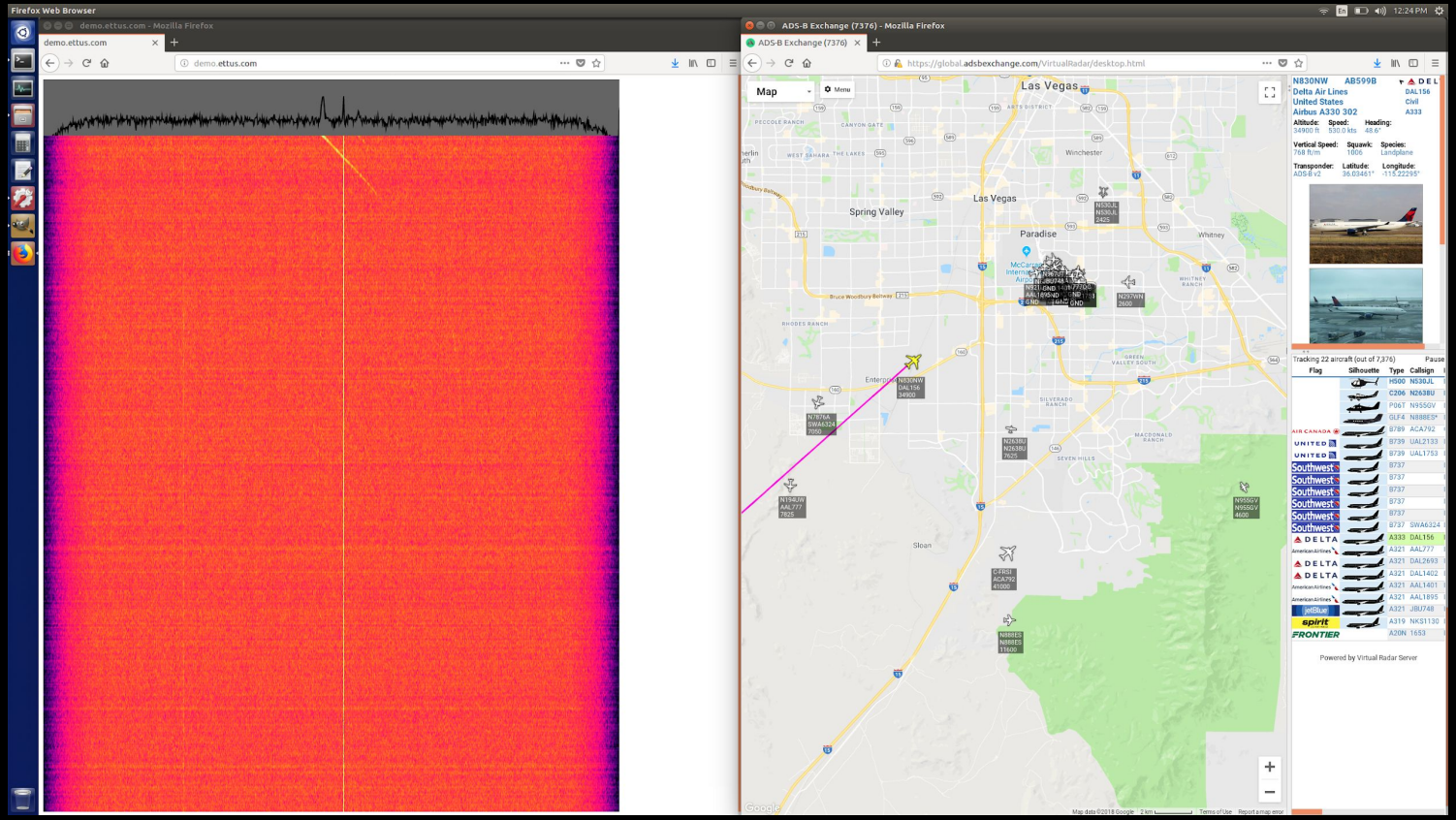

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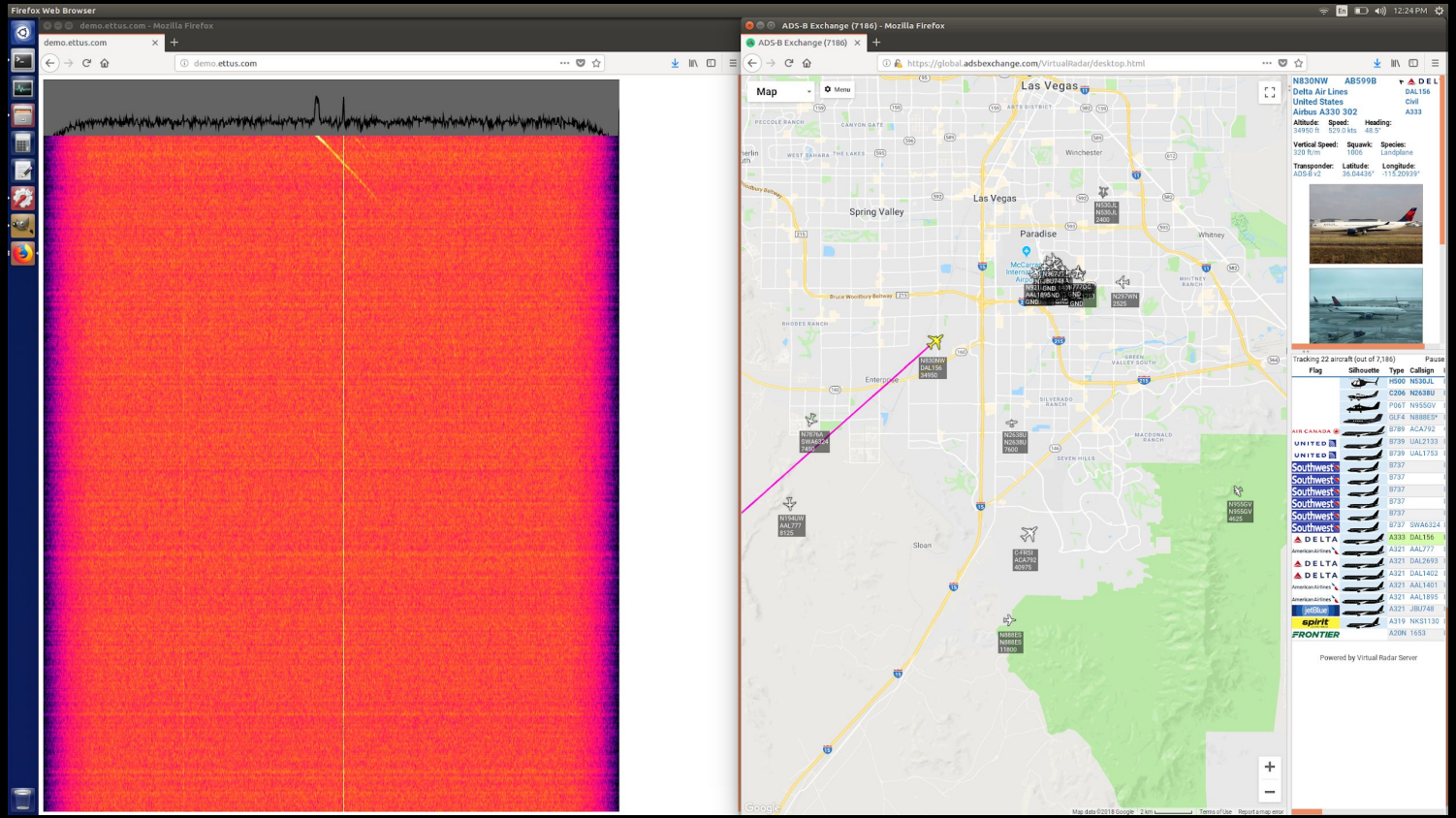

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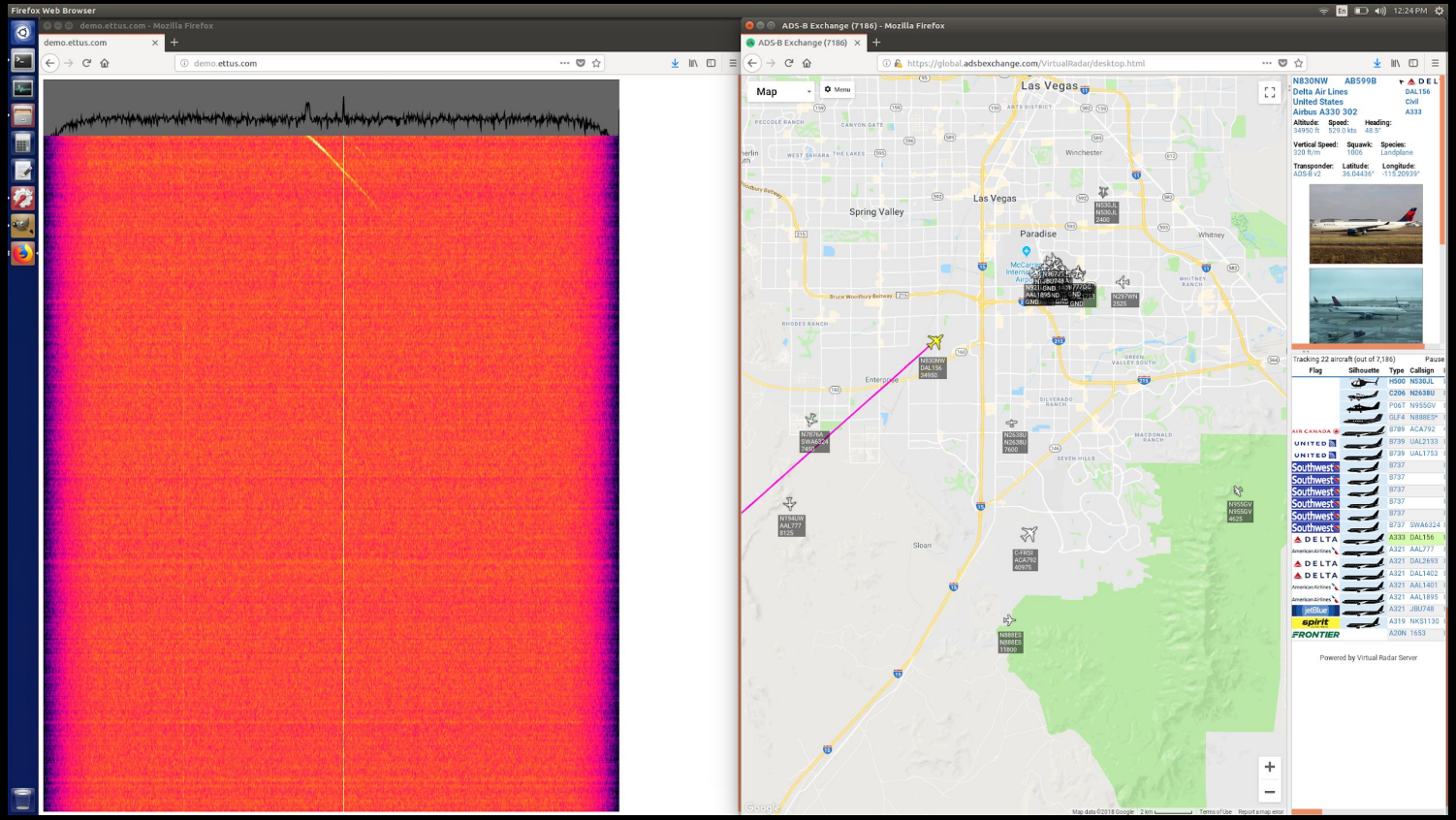

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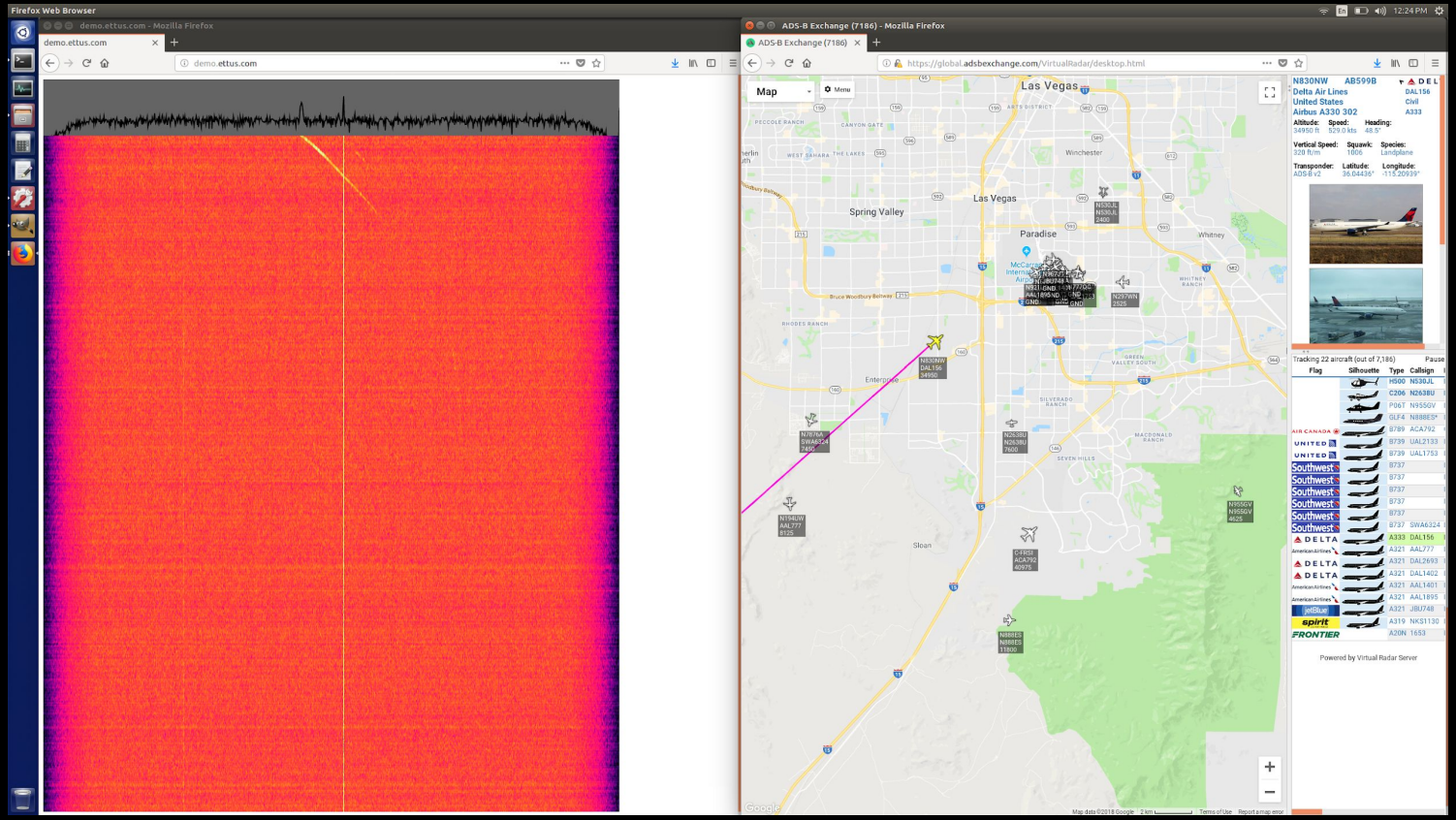

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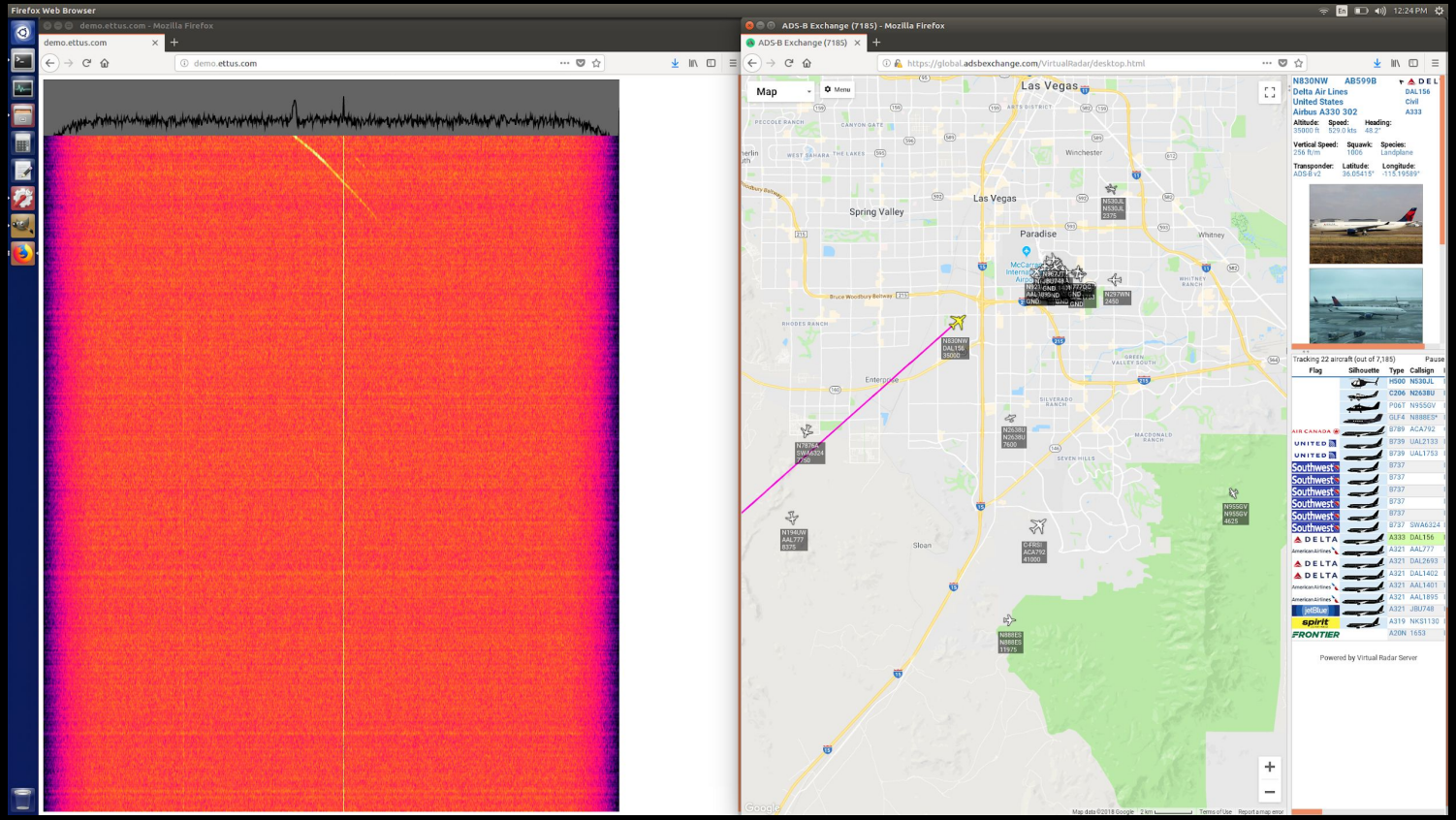

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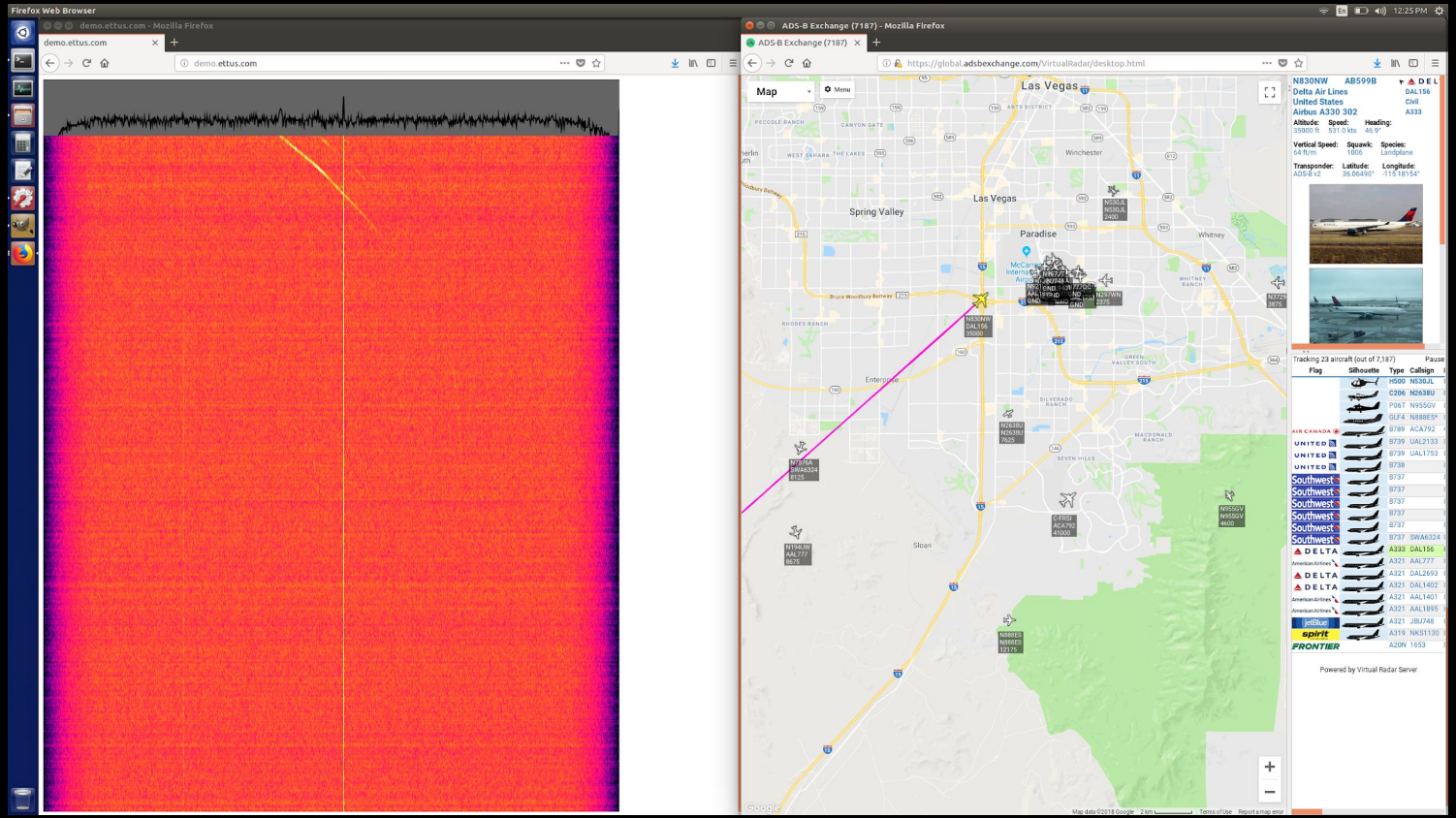

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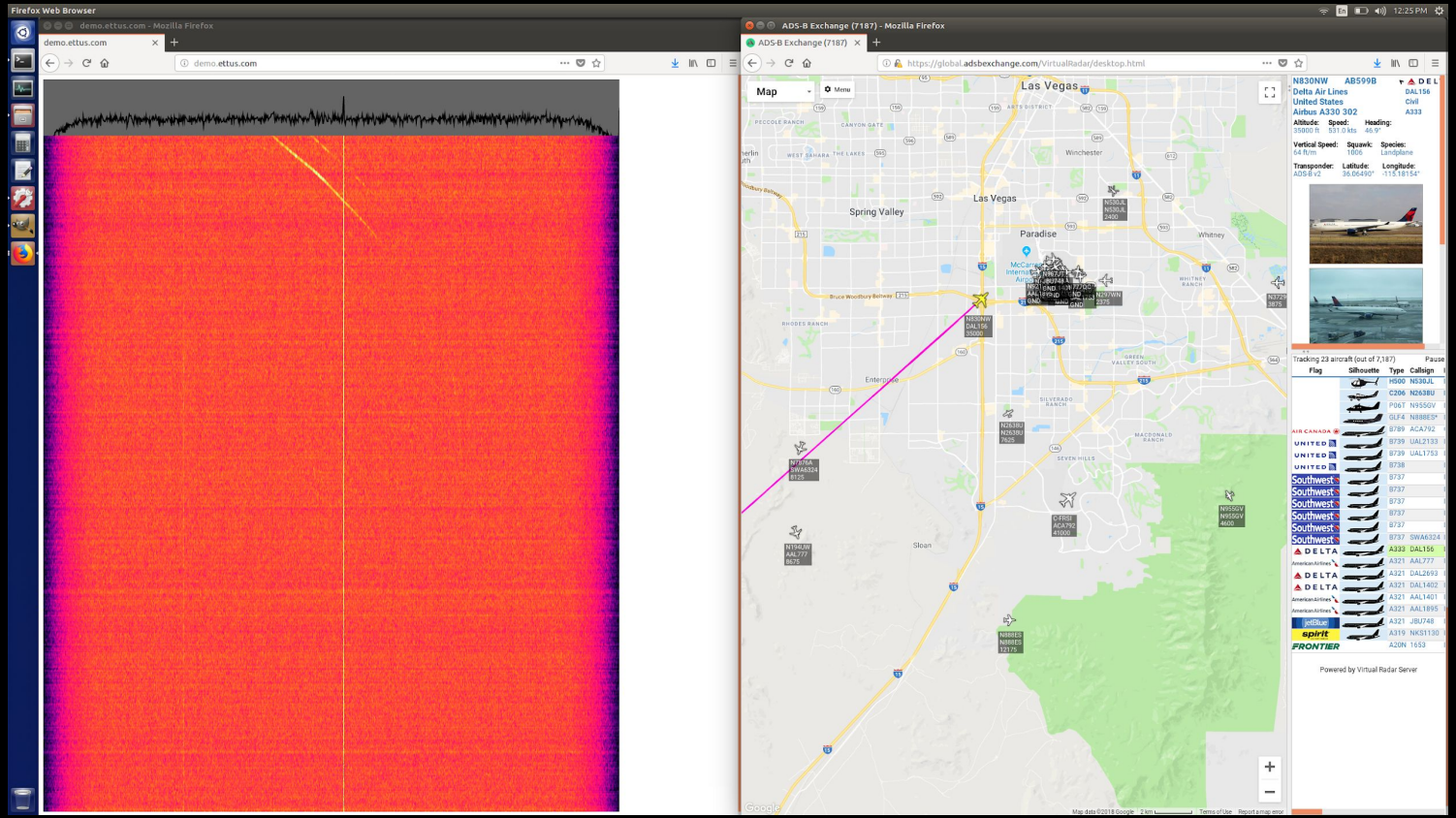

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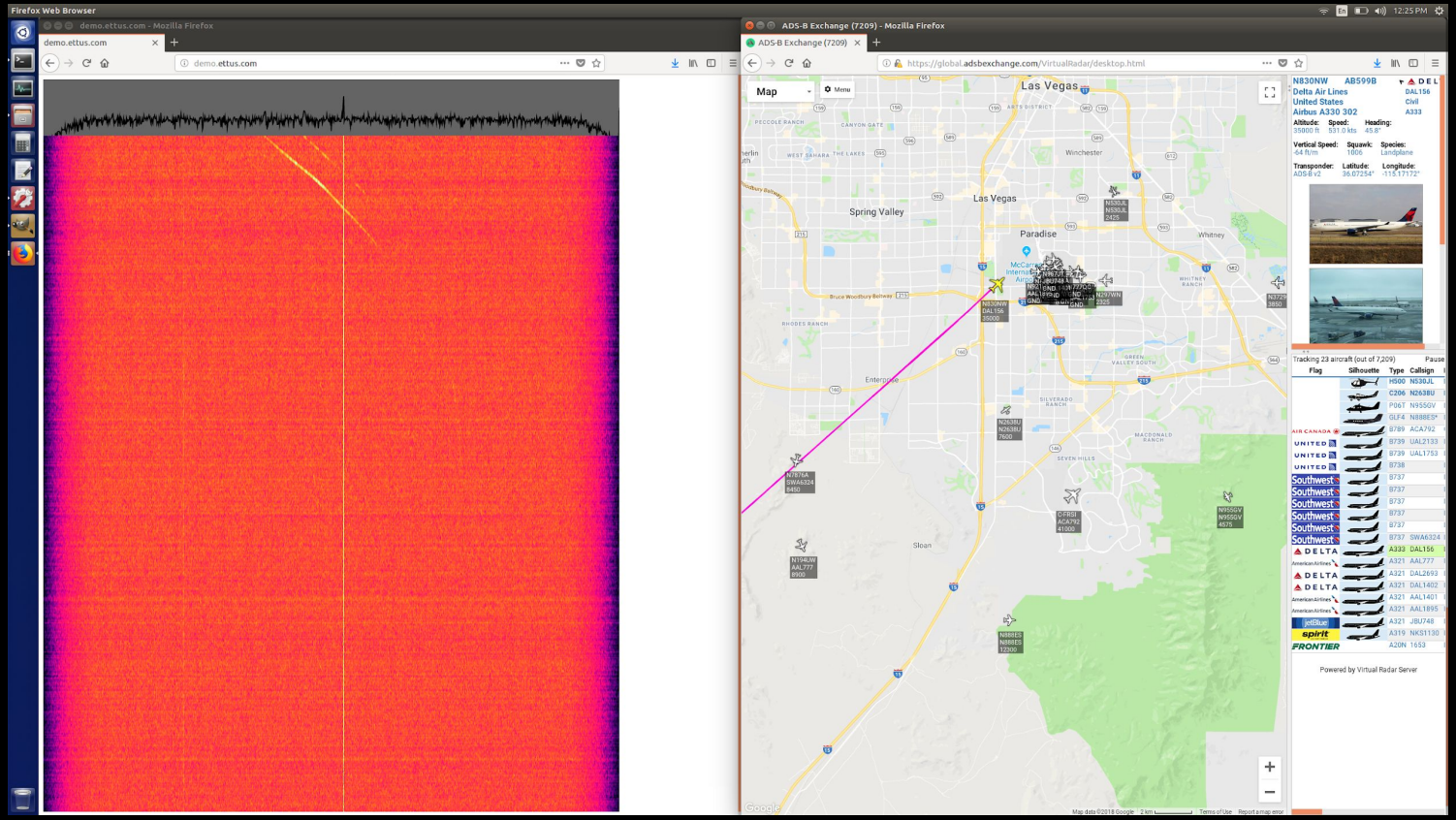

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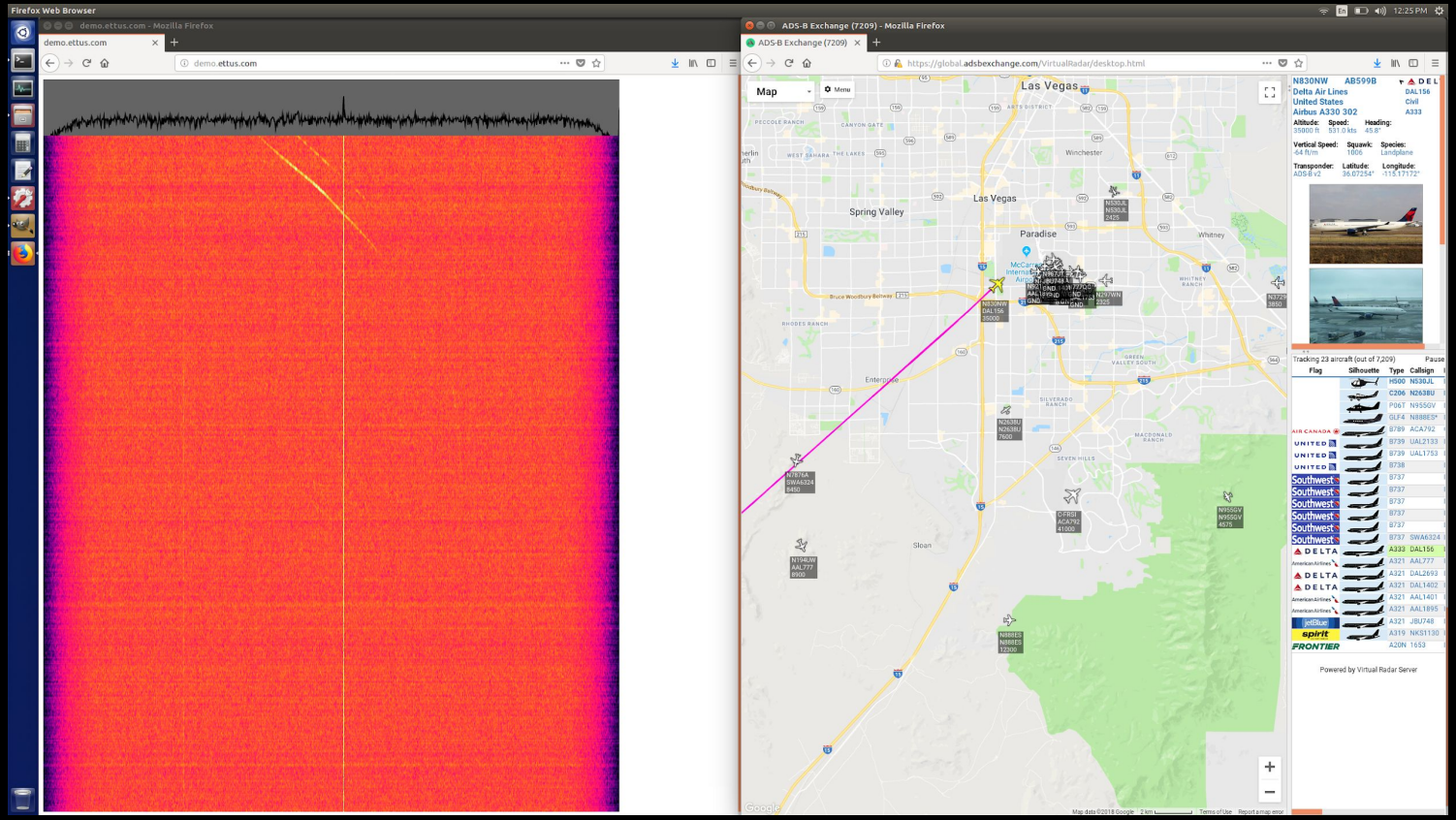

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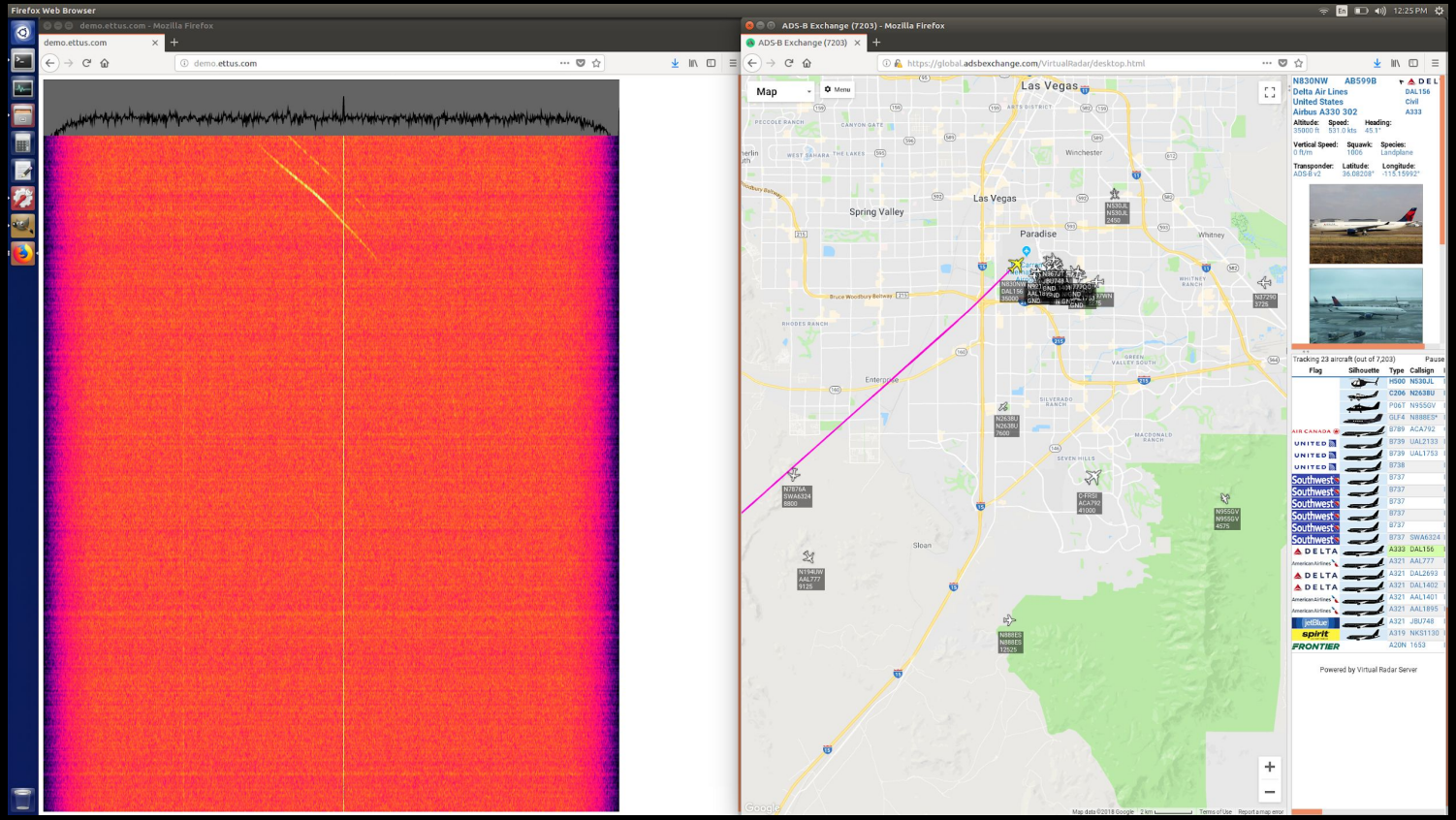

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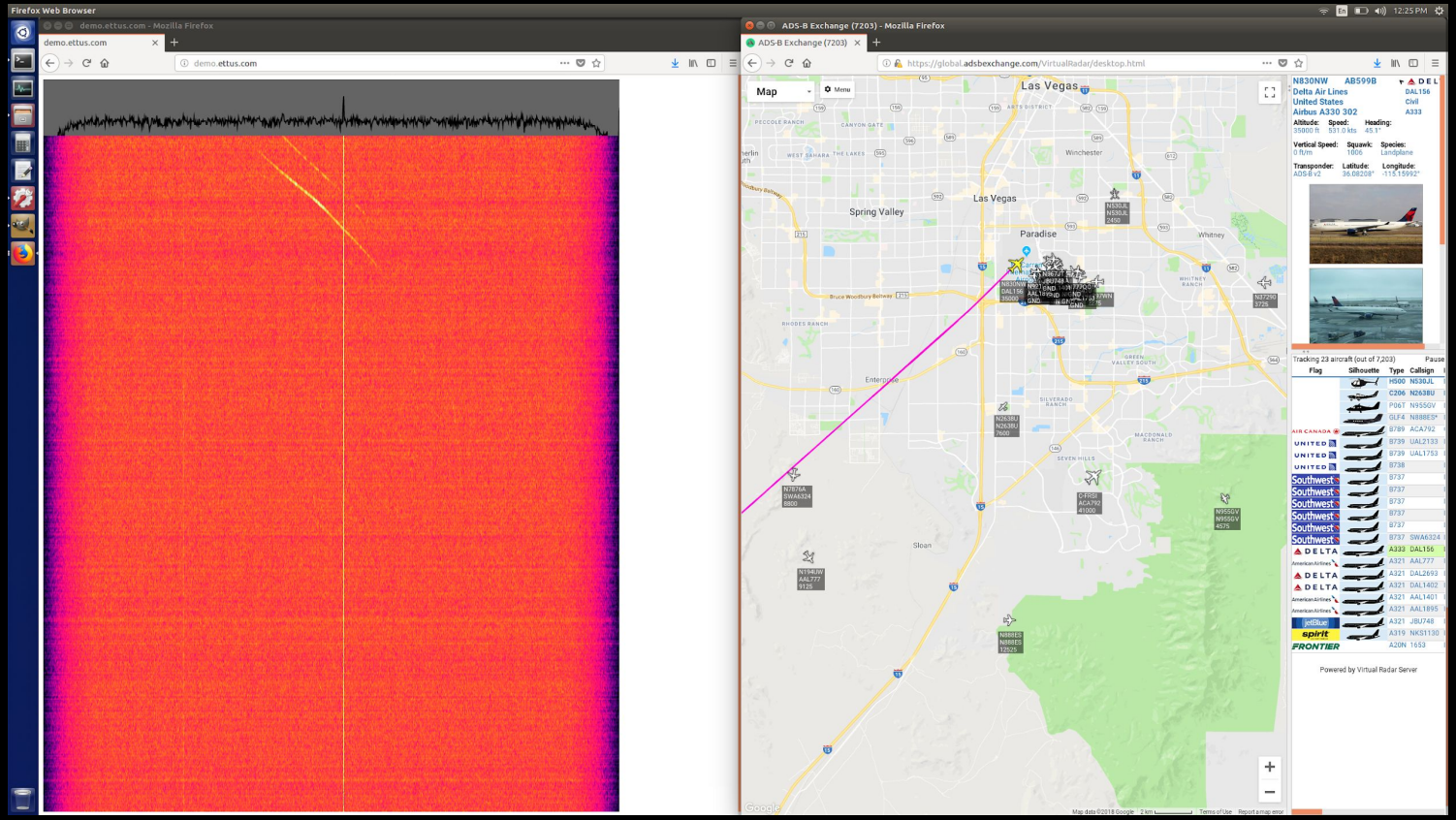

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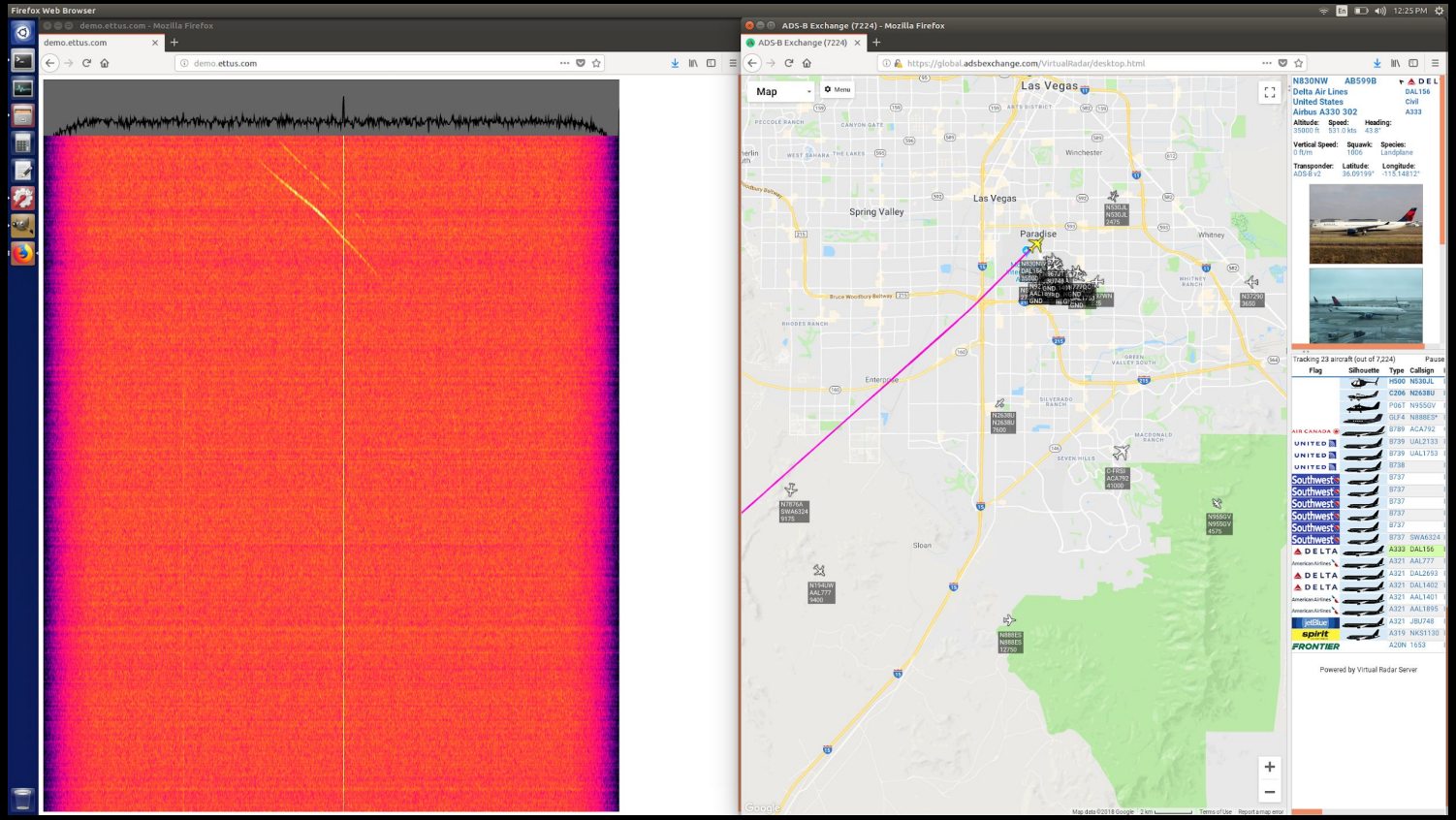

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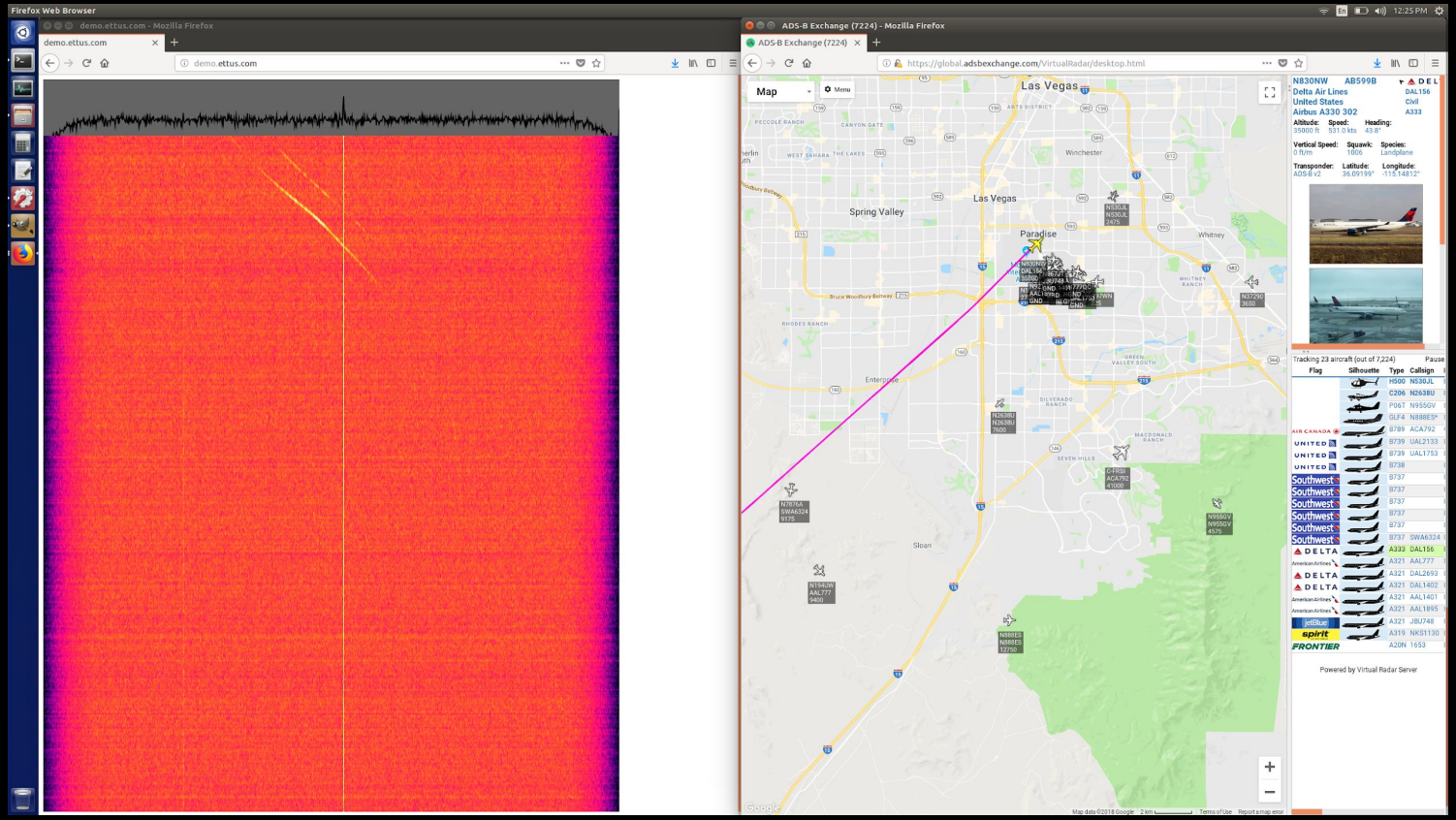

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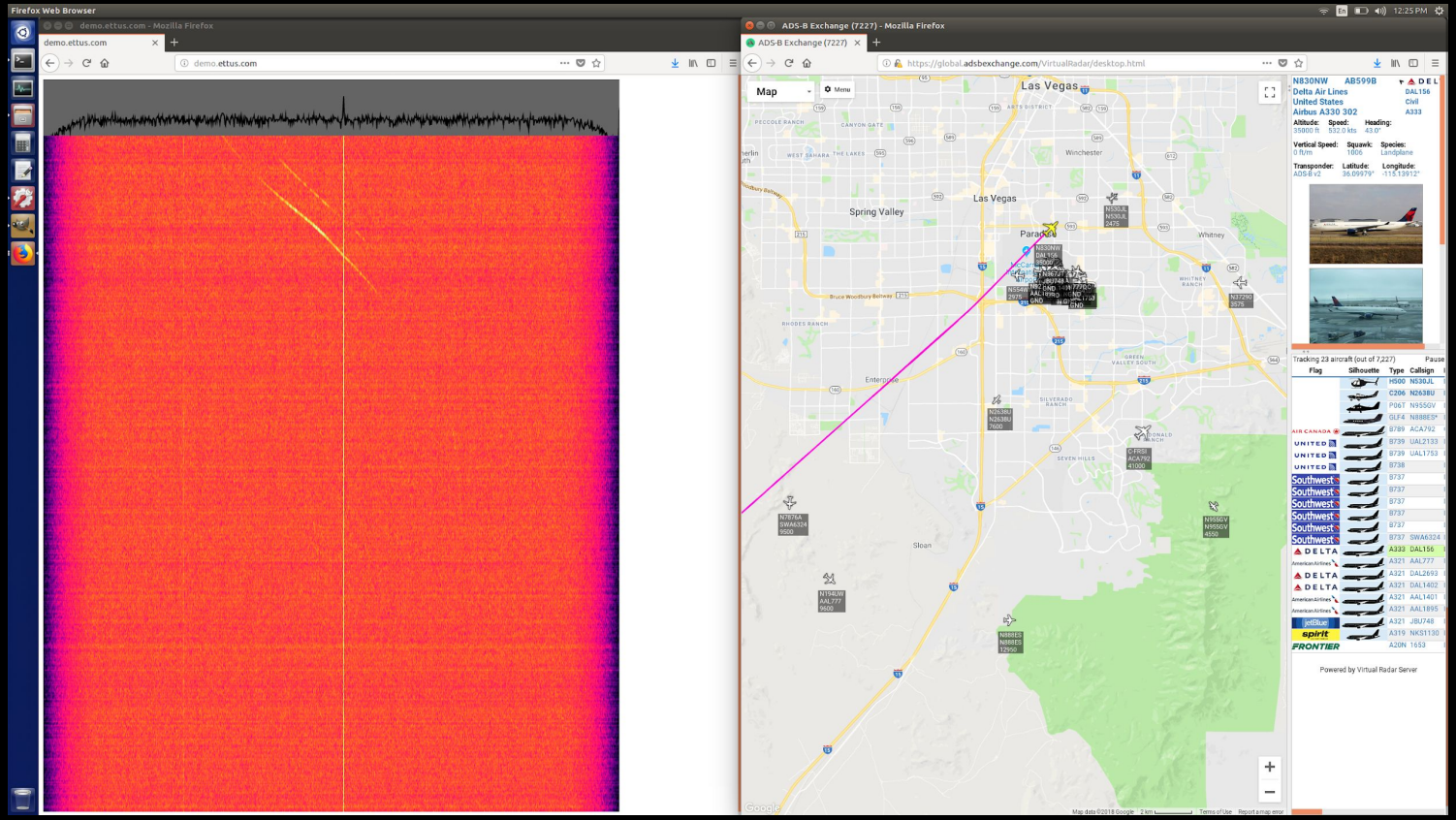

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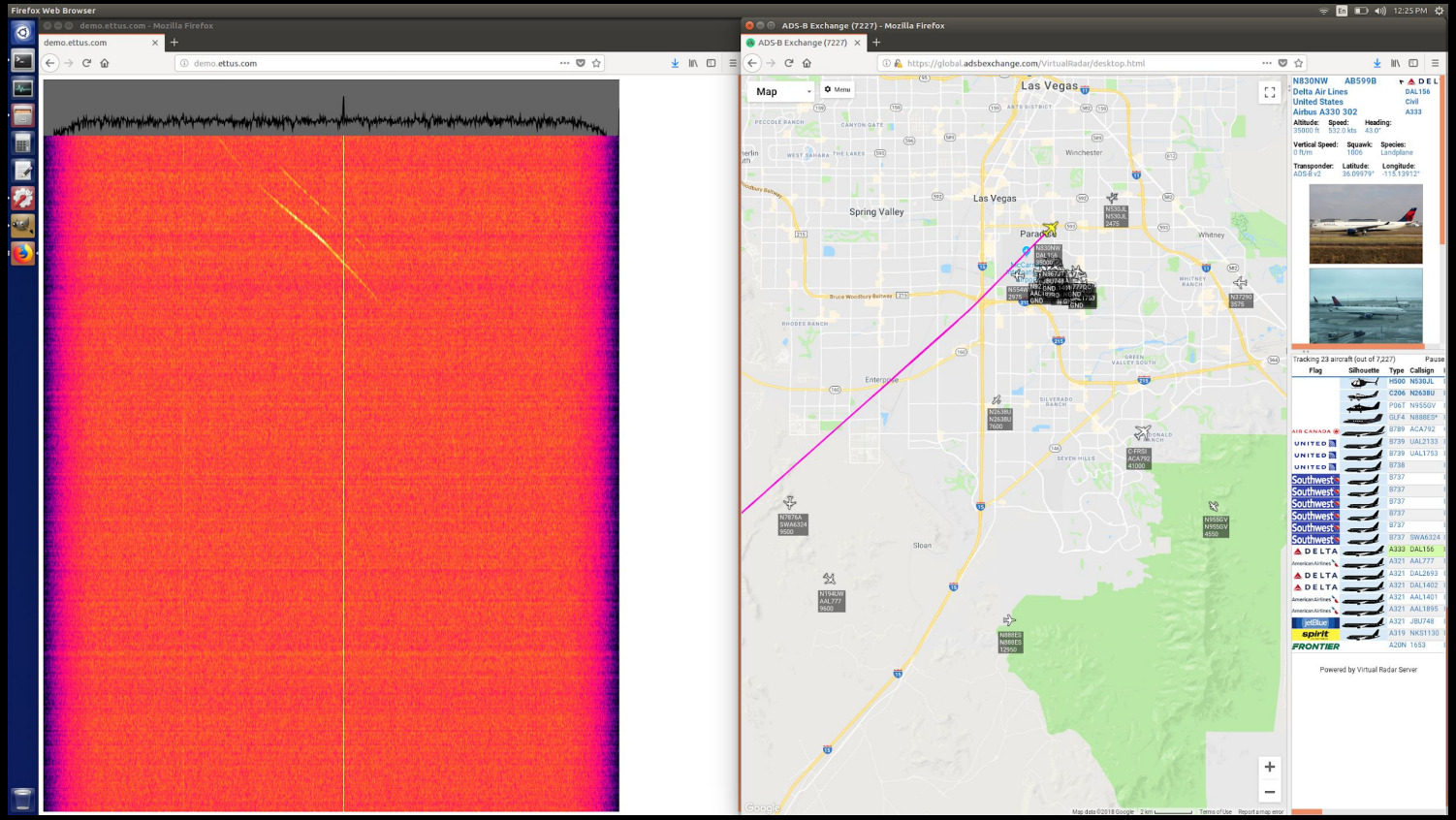

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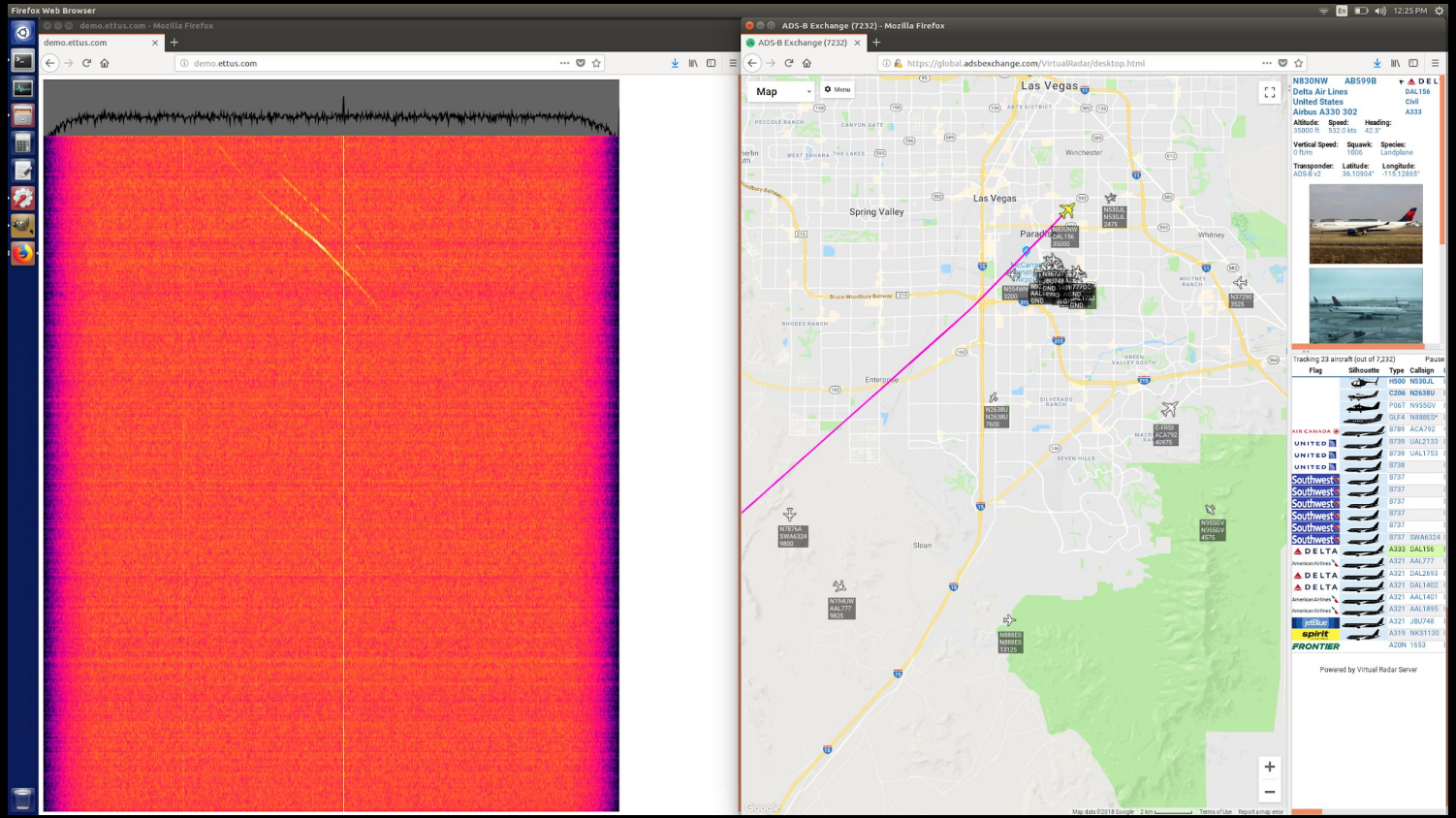

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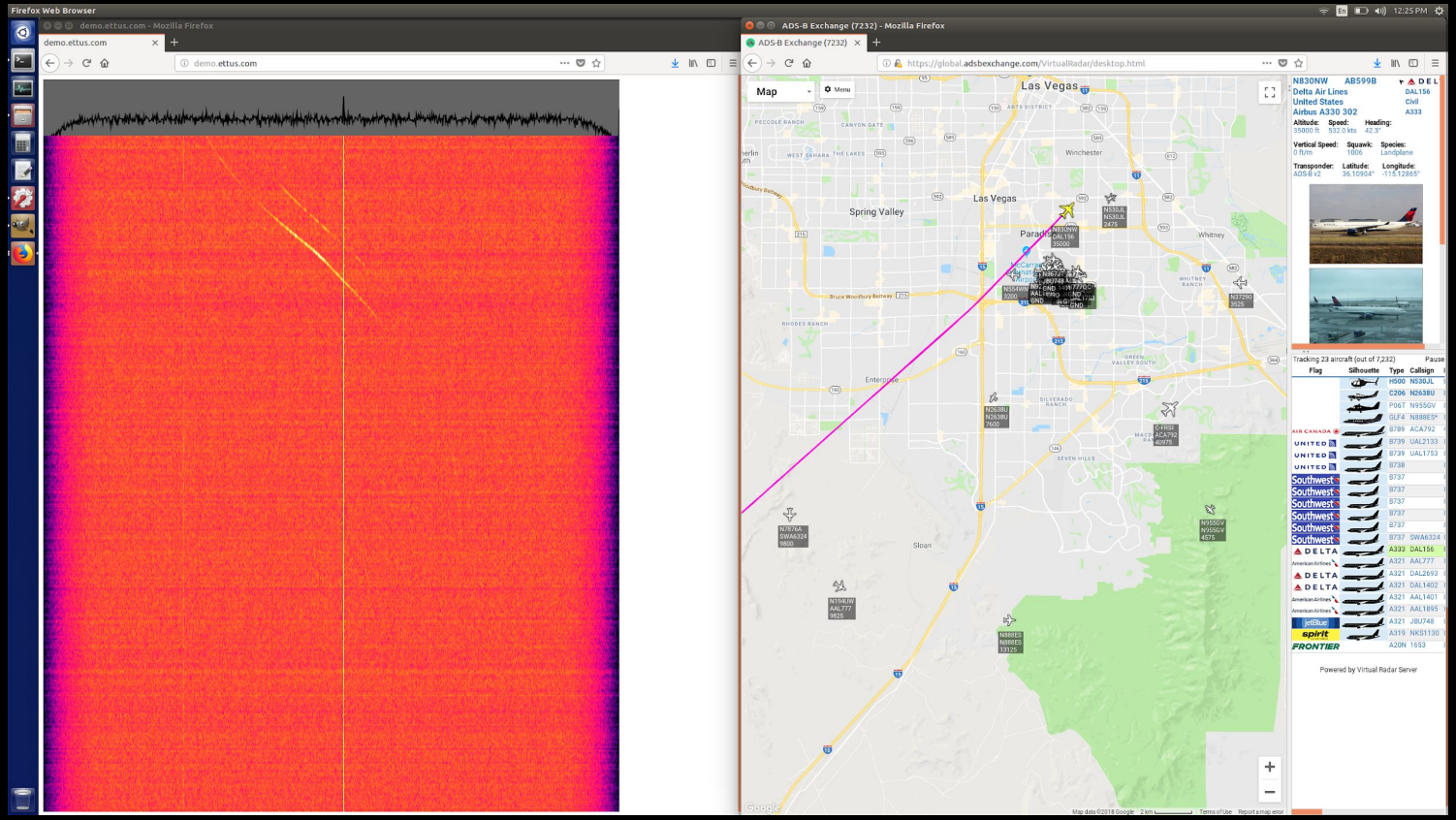

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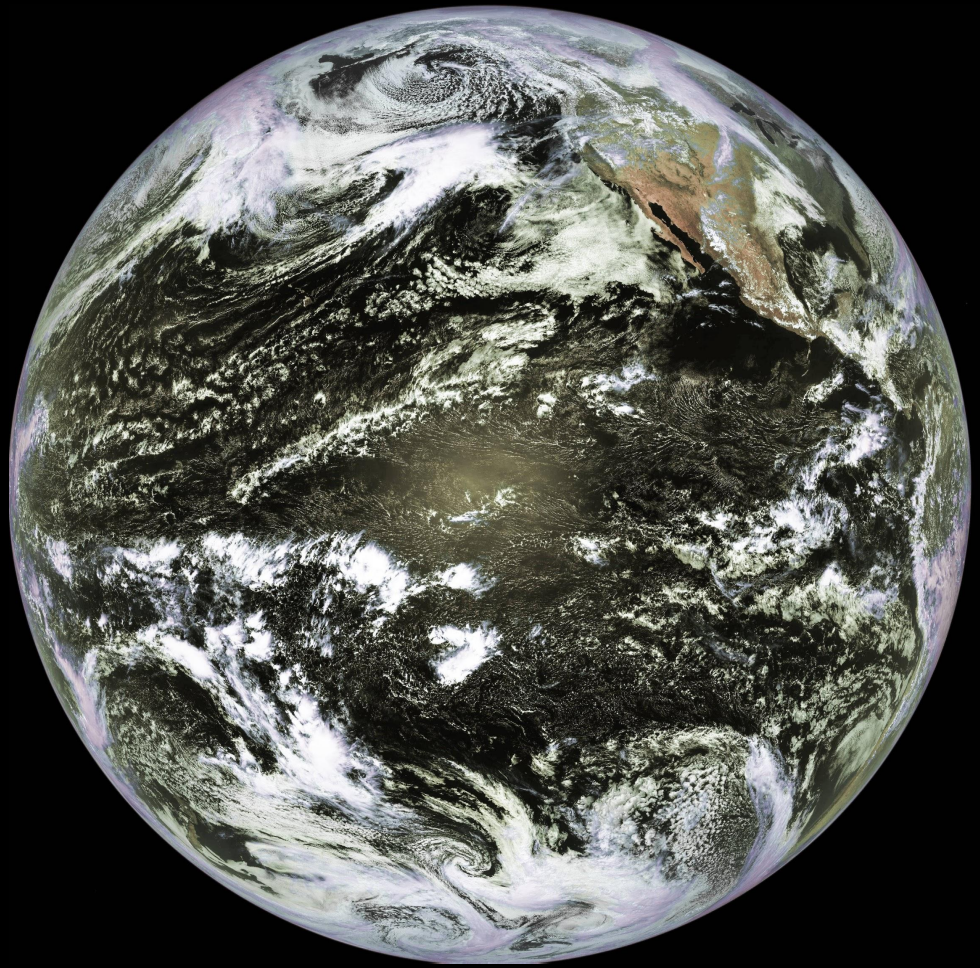

USRP E320 Magicwand

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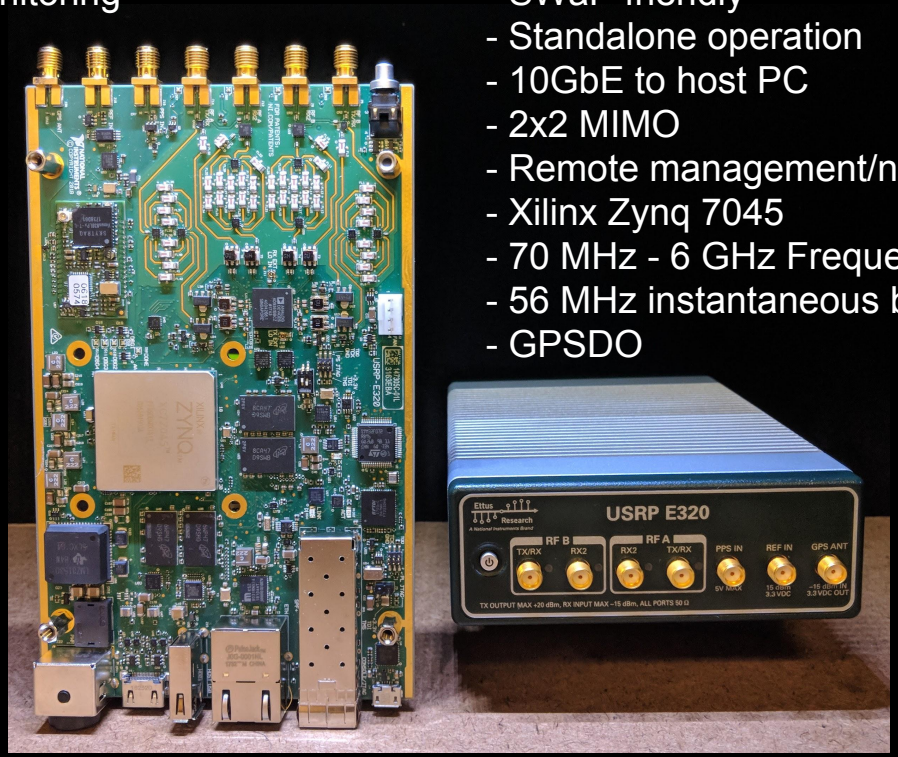
Applications include:
- Spectrum sensing/monitoring
- SIGINT
- UAV datalinks
- Drone defense
- TDOA/DF
- UE emulation
- Rapid prototyping
- And many more!



Key features include:
- SWaP friendly
- Standalone operation
- 10GbE to host PC
- 2x2 MIMO
- Remote management/networking
- Xilinx Zynq 7045
- 70 MHz - 6 GHz Frequency Range
- 56 MHz instantaneous bandwidth
- GPSDO

Come see it live at the Ettus booth!

Future Magicwands

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Please come talk to me if you have these requirements for future magicwands!

- Phase coherent systems
- Lower latency
- Wider bandwidths
- Lower frequencies (HF)
- Higher frequencies (uWave, mmWave)