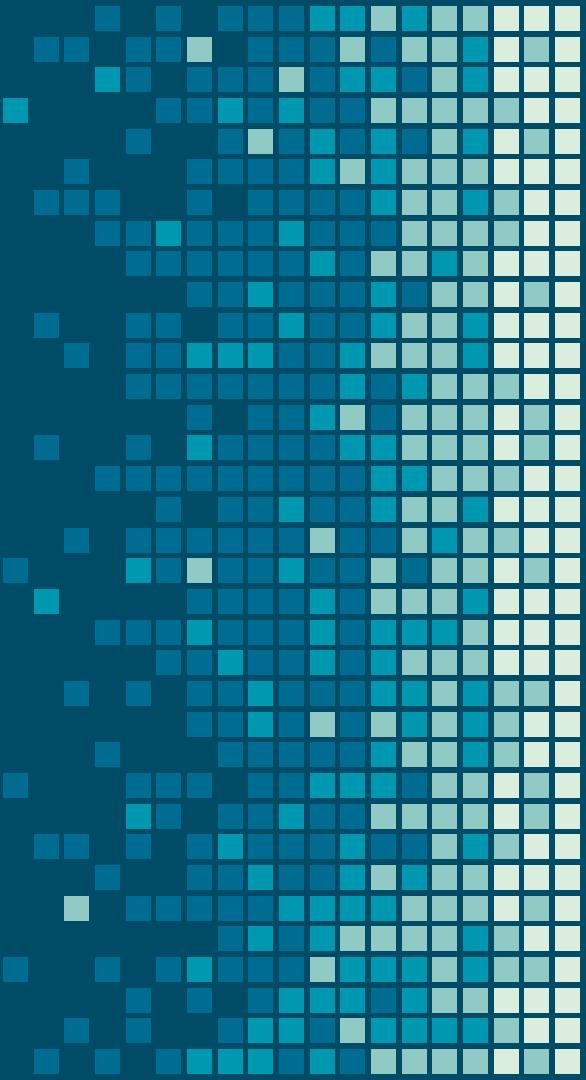


# Open Source Satellites



# INSTRUCTIONS FOR USE

Weigh and Consider! (Harold Bloom “How to Read and Why”)

Disobey!

Experiment!  
Participate!  
Enjoy!



More info on how to use this and many other presentation templates at  
[www.slidescarnival.com/help-use-presentation-template](http://www.slidescarnival.com/help-use-presentation-template)

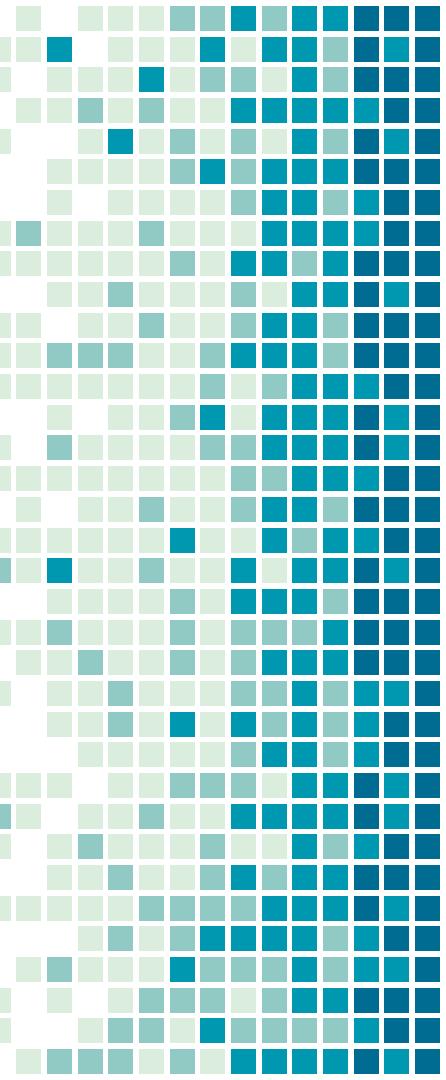
Templates used are free to use under Creative Commons Attribution license. You can keep the Credits slide or mention SlidesCarnival and other resources used in a slide footer.

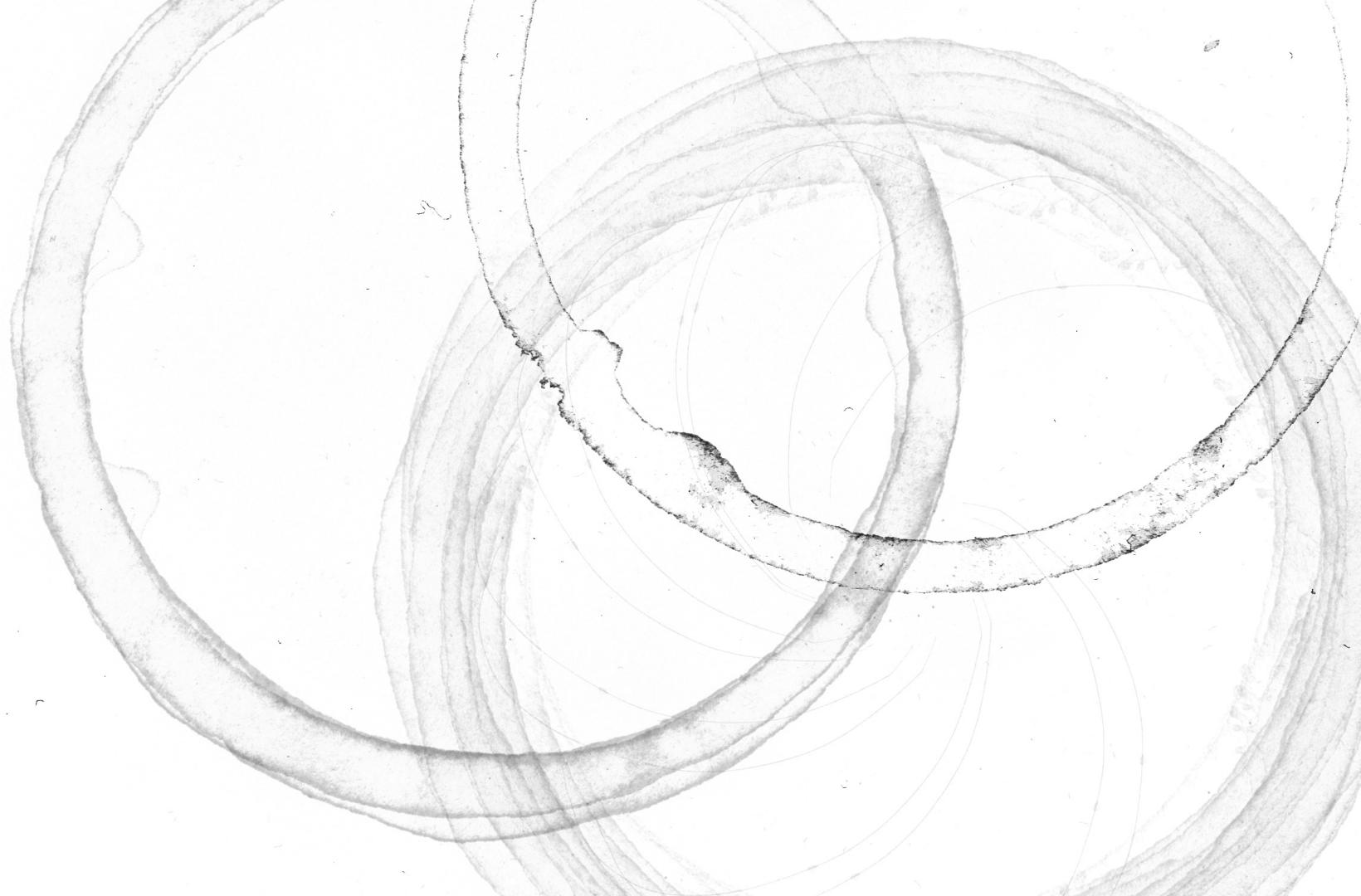
# HELLO!

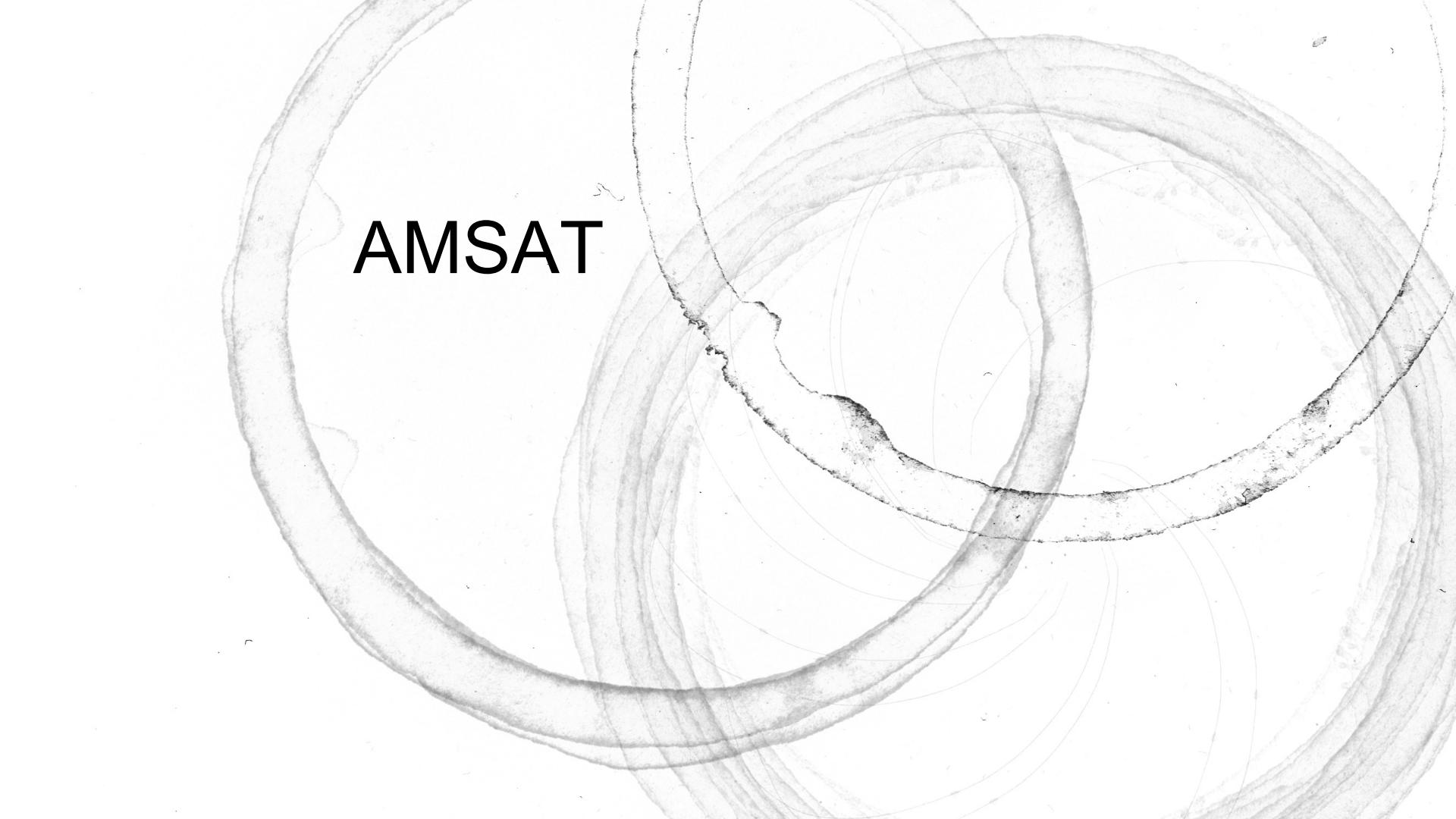
I am **Michelle W5NYV**  
I enjoy thinking and doing!  
Not necessarily in that order!

BSETx2, math minor, MSEE Info Theory  
USC, DEFCON, Burning Man, AMSAT,  
IEEE, GNU Radio, Gator (punk rock), 2nd  
lines, street bands, community orchestras,  
pipe organ construction, Organ Donor lead,  
Phase 4 Ground lead

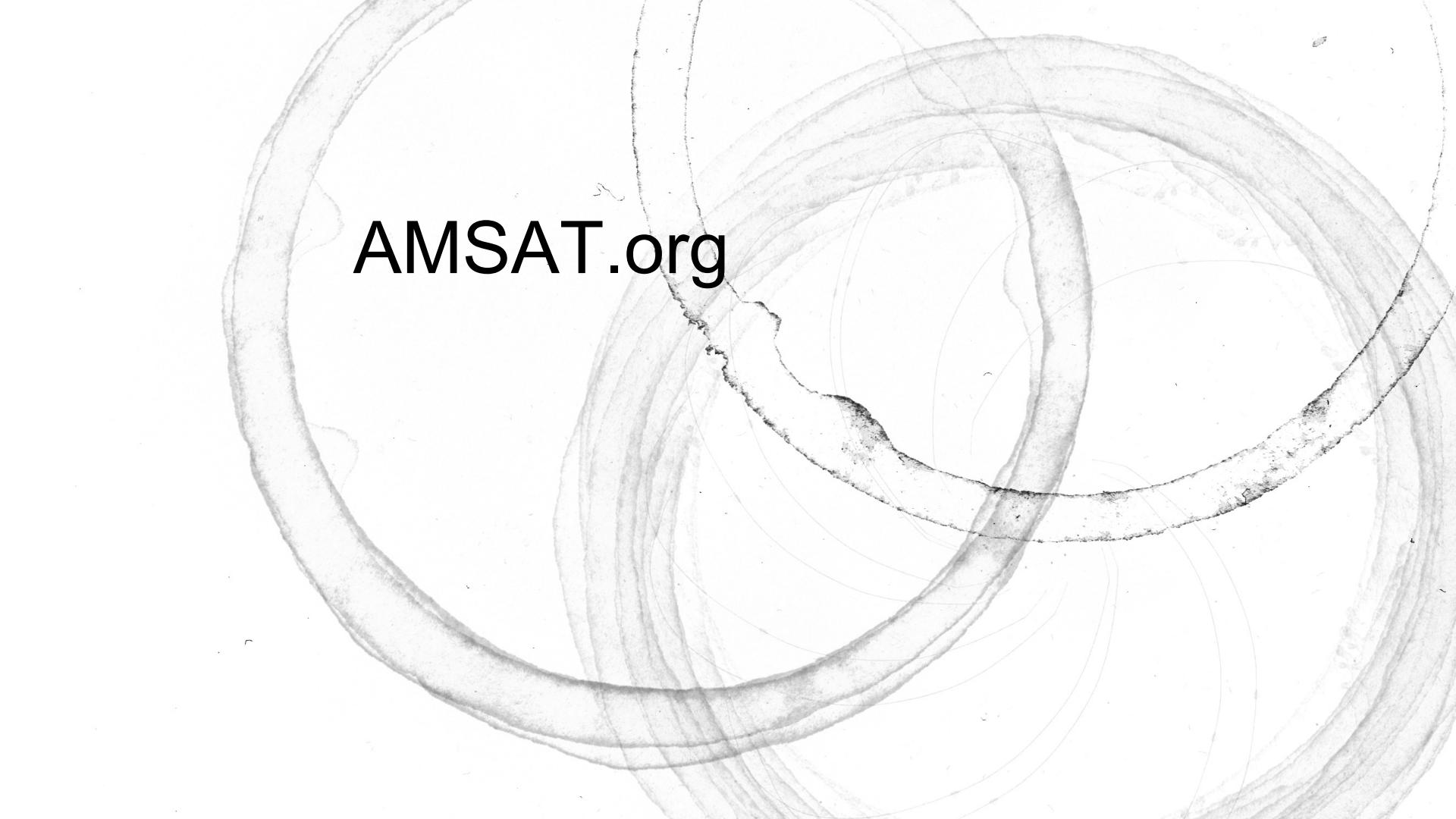
<https://phase4ground.github.io/>



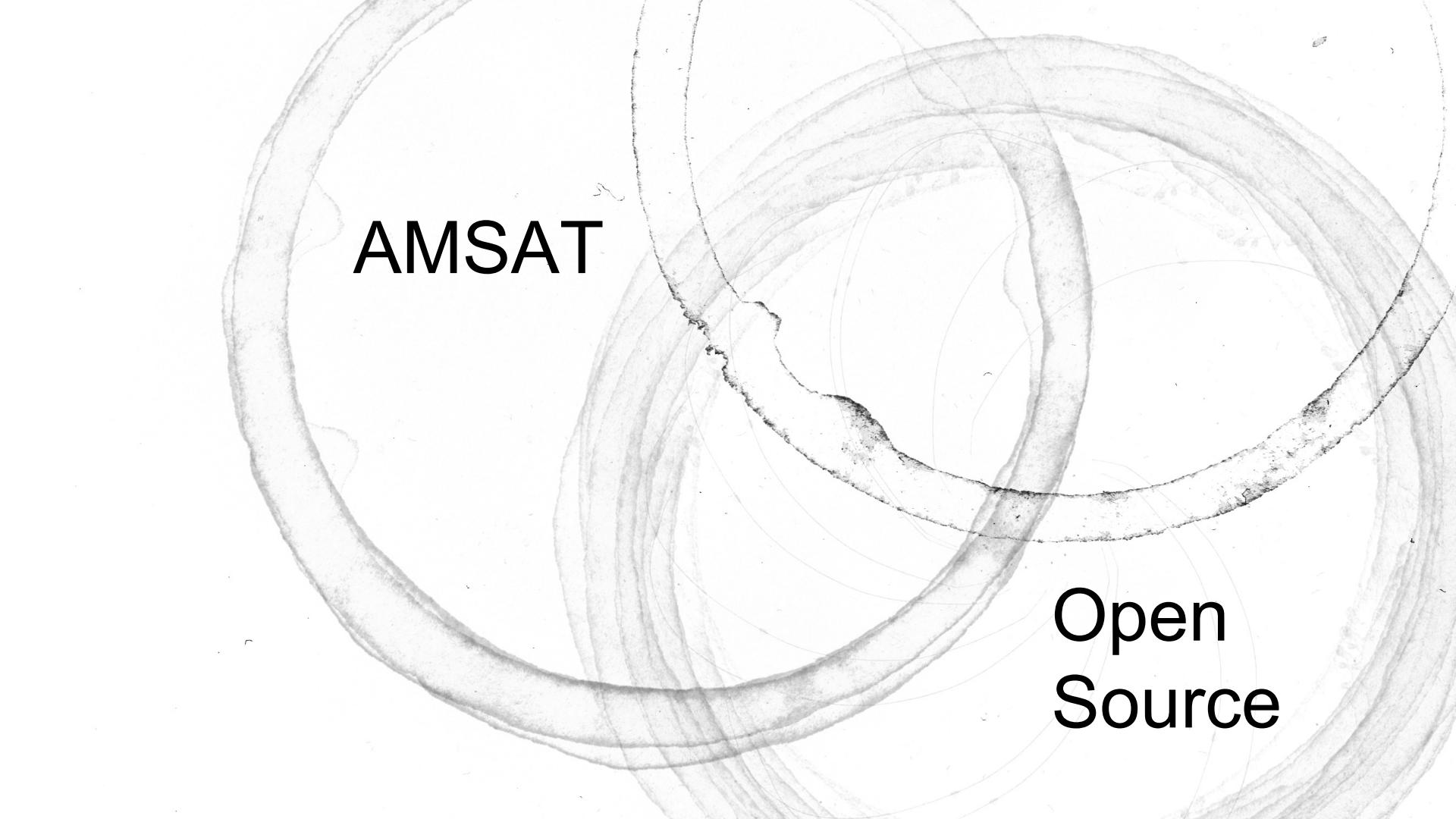




**AMSAT**

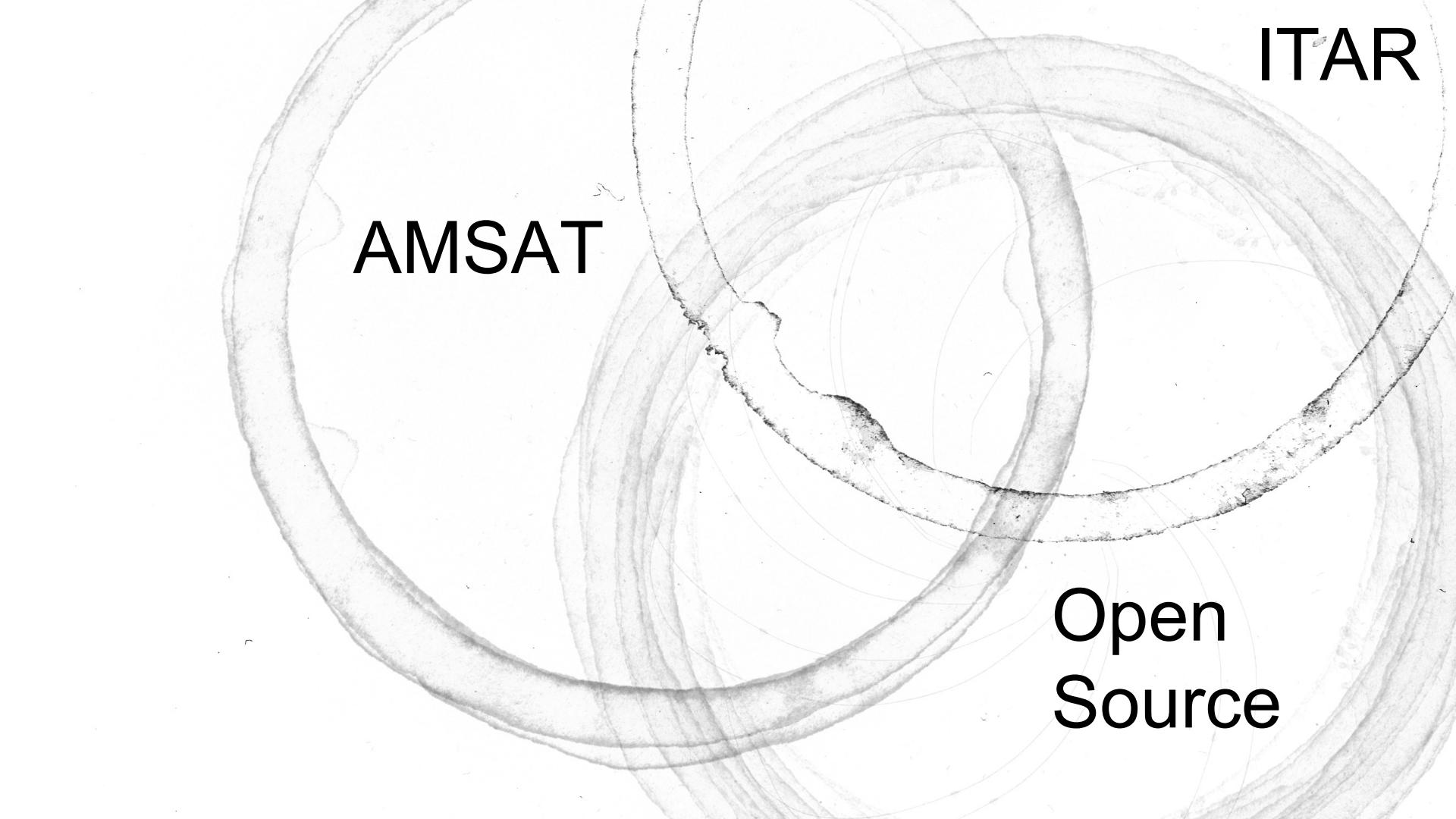


**AMSAT.org**



AMSAT

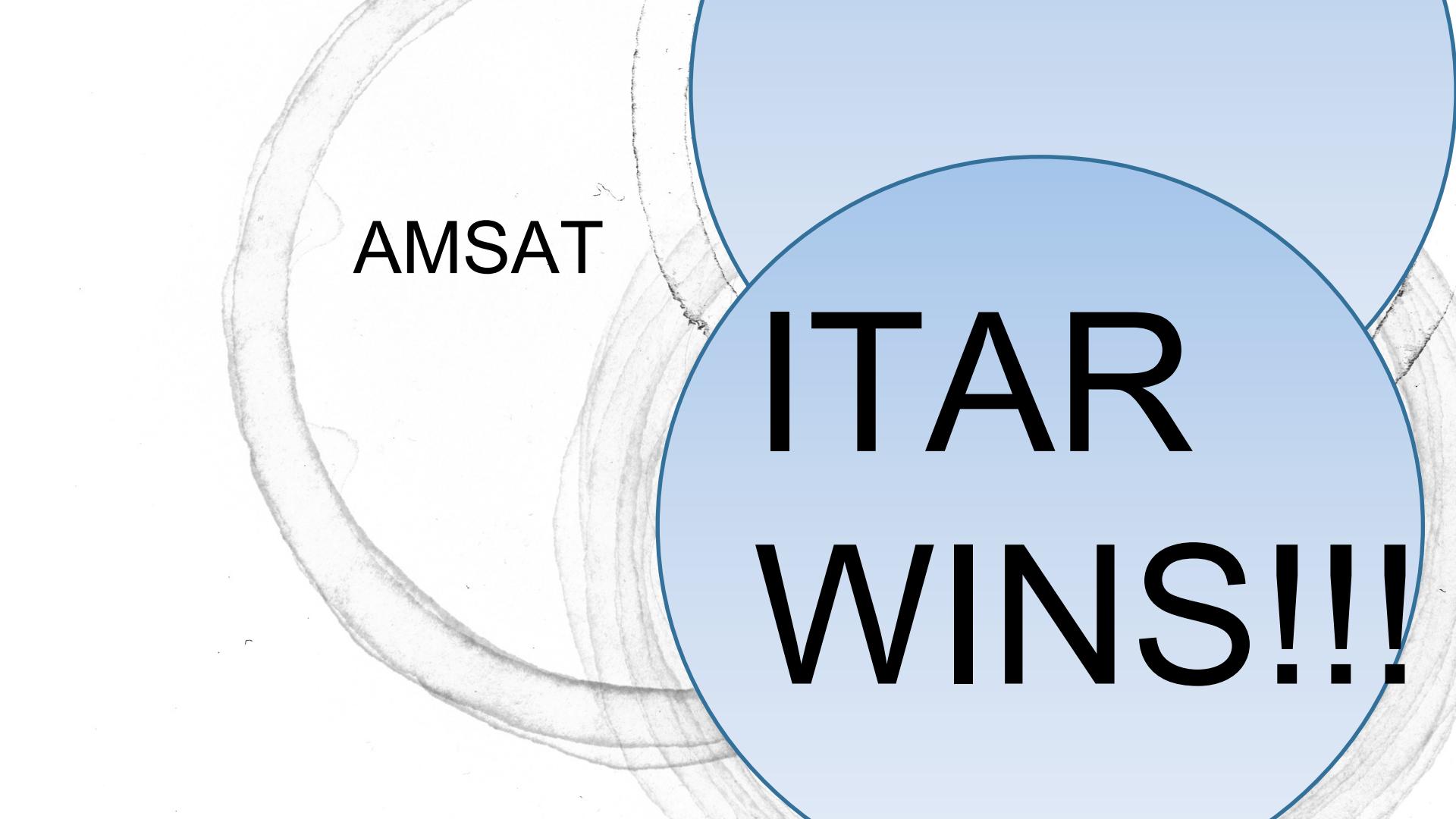
Open  
Source



ITAR

AMSAT

Open  
Source

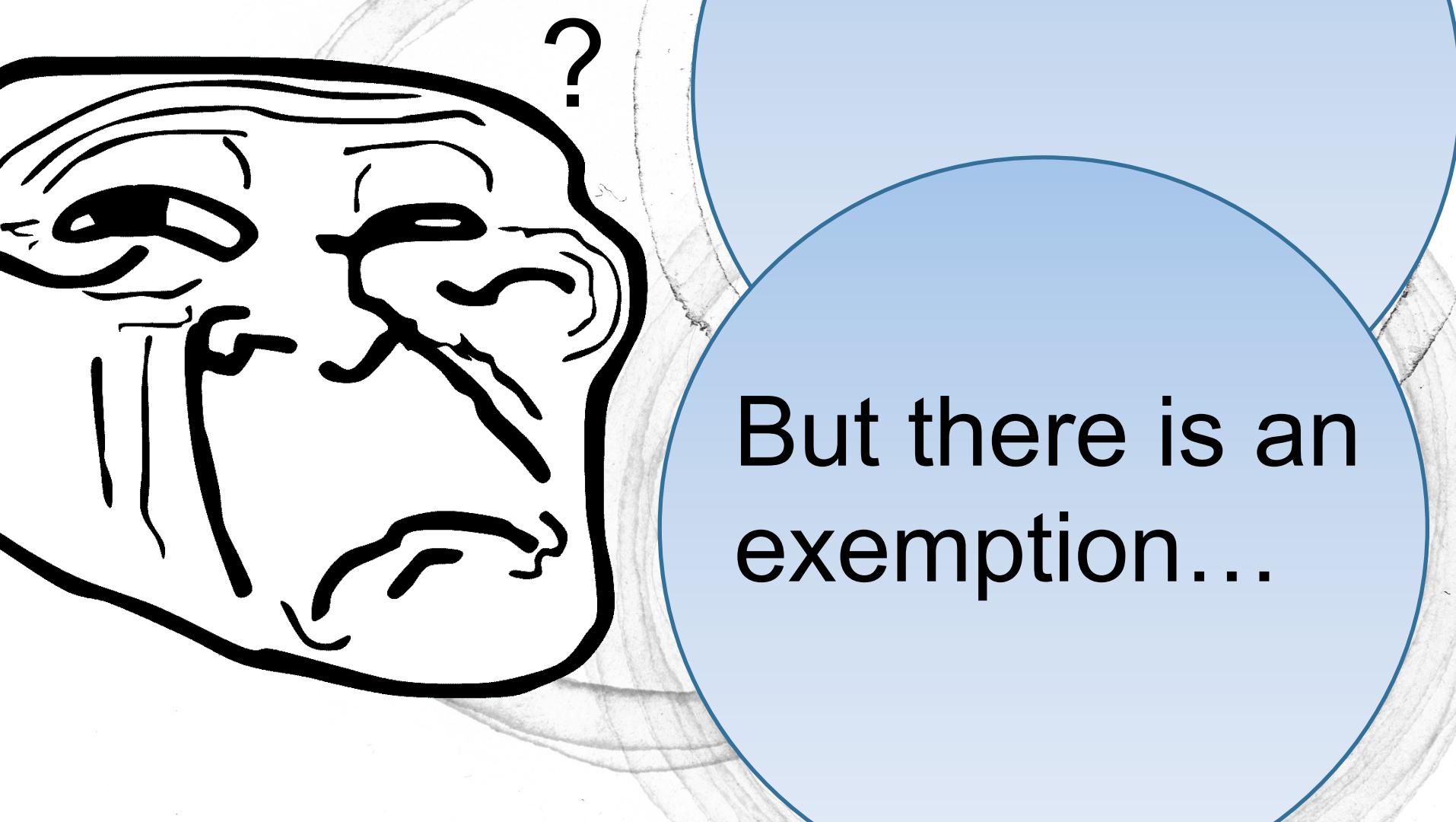


AMSAT

ITAR  
WINS!!!



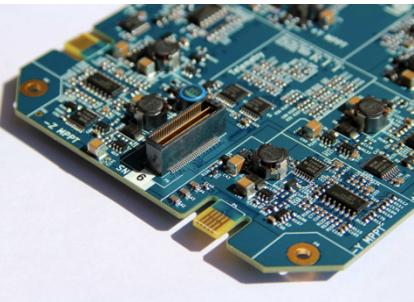
**ITAR  
WINS!!!**



But there is an  
exemption...

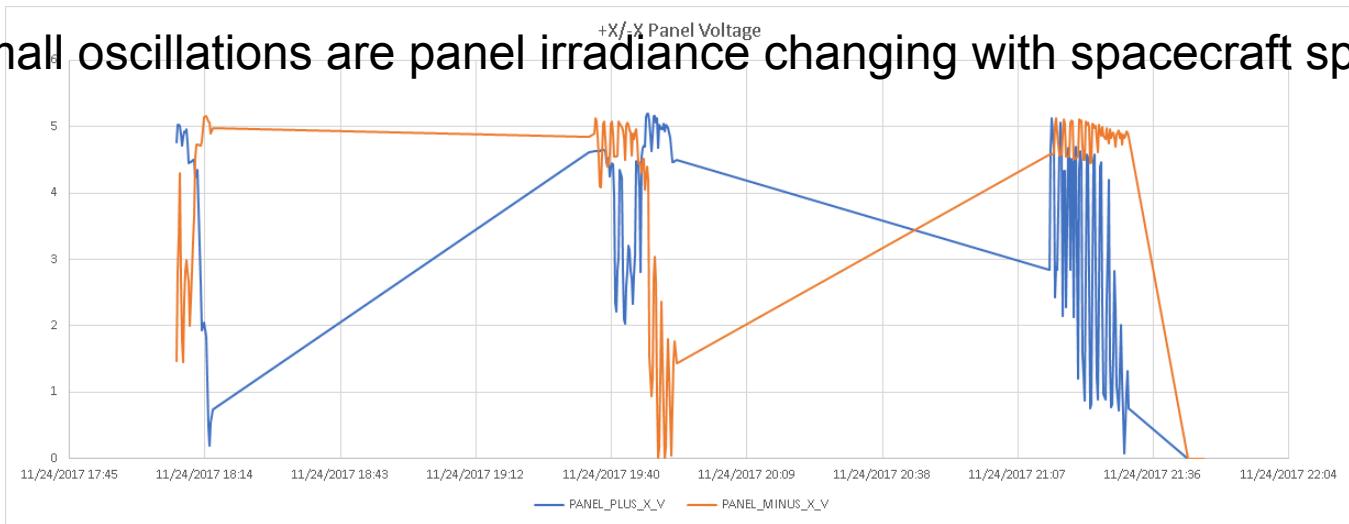
# Fox-1 Maximum Power Point Tracker

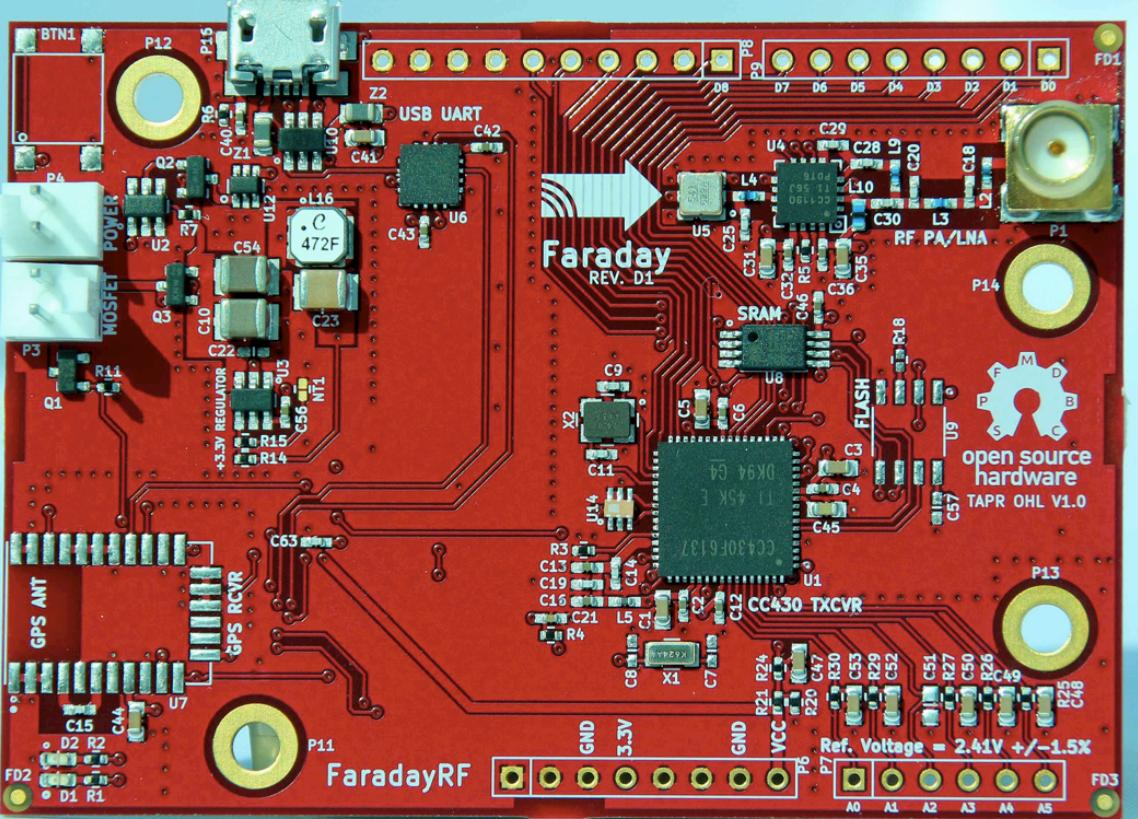
- Started at Rochester Institute of Technology (RIT) in 2012
- Two years development after graduation by Brenton & Bryce Salmi (**FaradayRF**)
- One analog computer per solar panel implementing  $Y = -mX + b$  to predict solar panel maximum power point voltage based on panel temperature
- Currently on-orbit in AO-91 (RadFxSat)
- [More Than Radios – AMSAT MPPT](#) blog post details the project
- [Design Files on GitHub](#)



# Fox-1 Maximum Power Point Tracker

- Peak power is obtained from solar cells between 4.3V at +60C and 5.8V at -60C
- Below are plots of -X and +X solar panel voltage on AO-91 shortly after launch
- You can see clearly how MPPT is performed on the panels around 4.8V
- Small oscillations are panel irradiance changing with spacecraft spinning



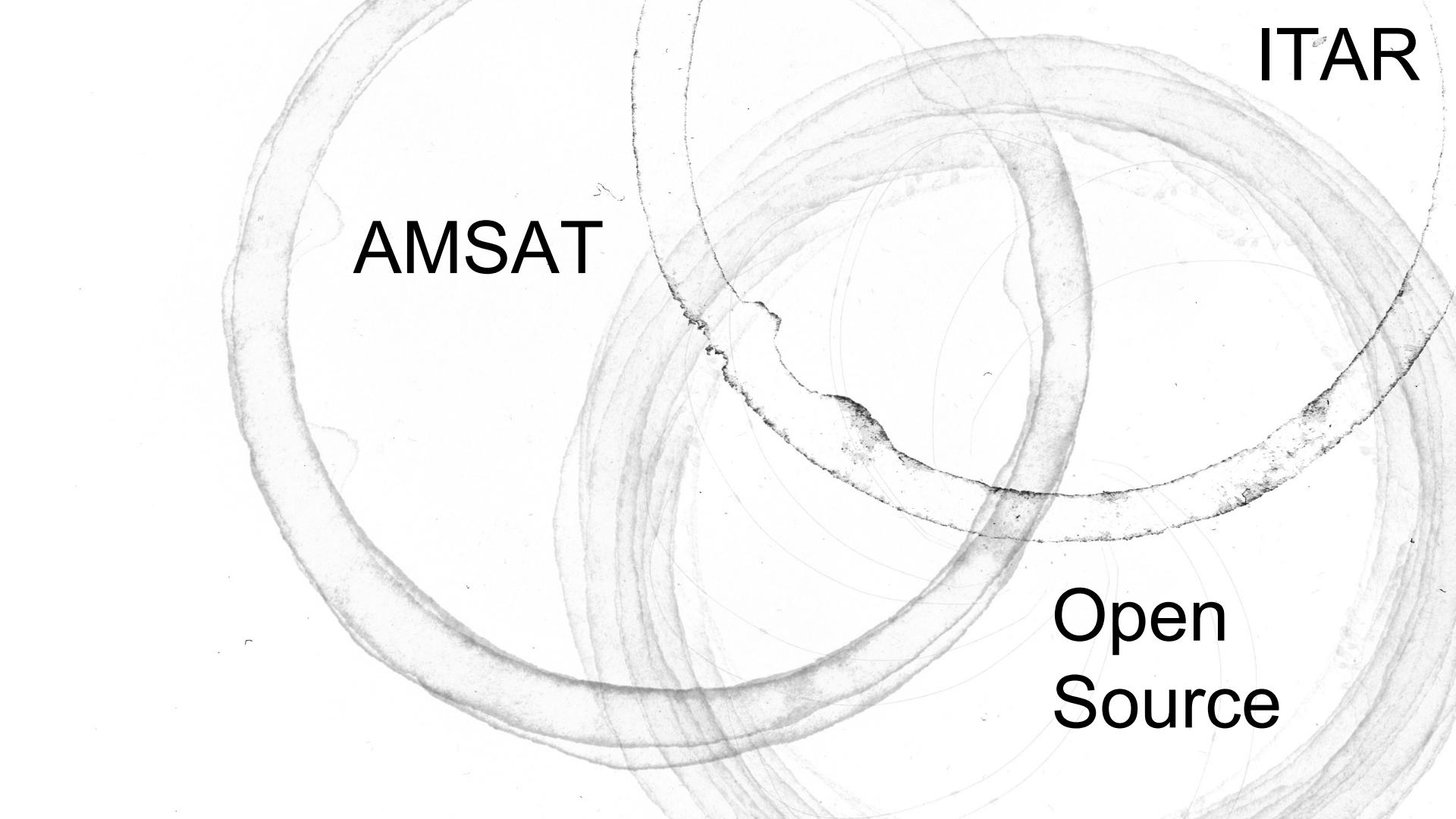


Faraday Wireless Radio

# Faraday Wireless Radio

- FaradayRF is an open source company who's mission is...
- “To educate and enable radio amateurs to advance the state of ham radio”
- Faraday is the first radio and licensed under TAPR OHL V1.0
- 400mW 2-FSK operation in the 33cm ham band
- 500kbaud maximum provides medium speed communications
- Fully open-source software and firmware [on GitHub](#)

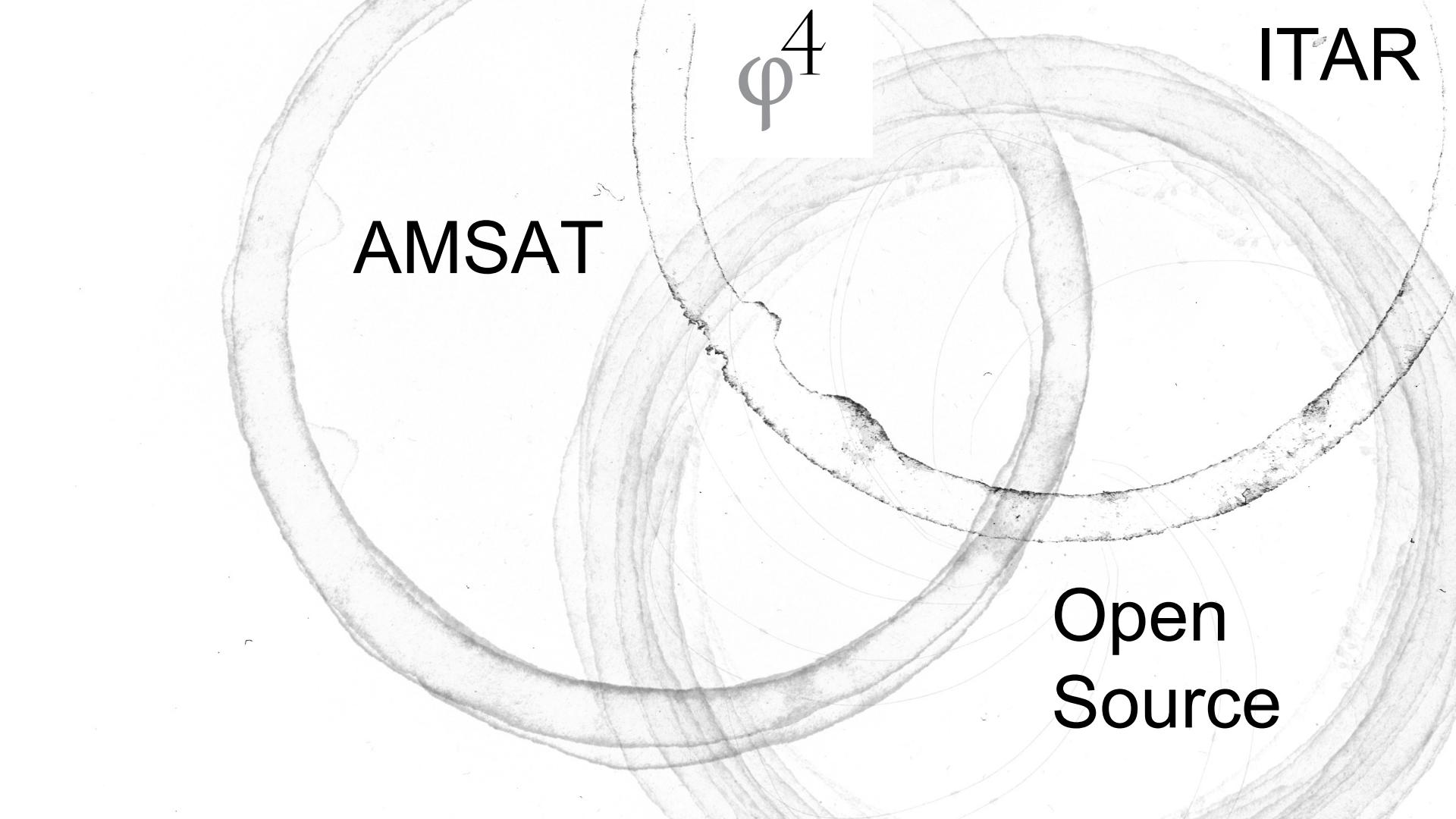




ITAR

AMSAT

Open  
Source

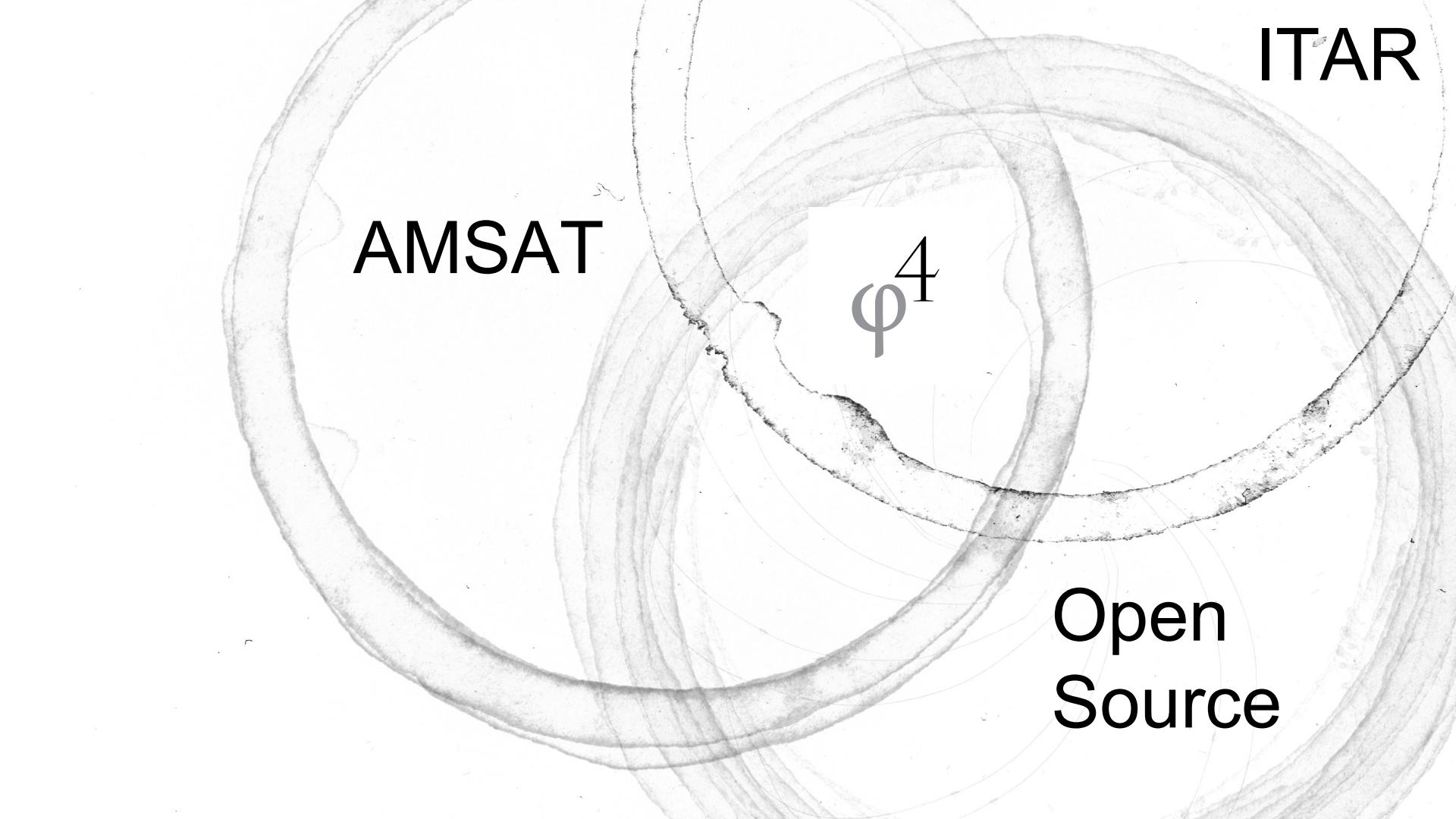


ITAR

$\phi^4$

AMSAT

Open  
Source

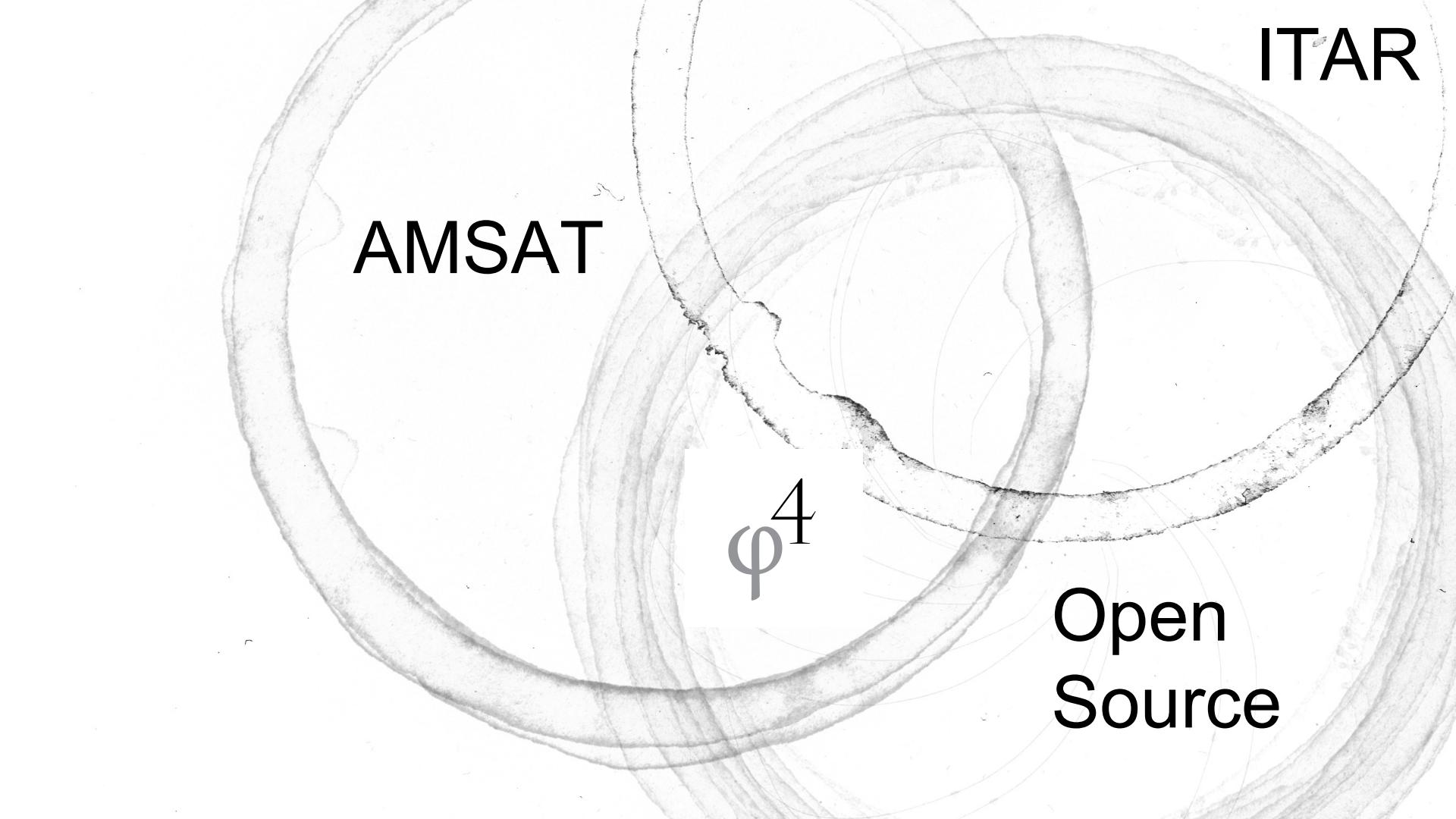


ITAR

AMSAT

$\varphi^4$

Open  
Source

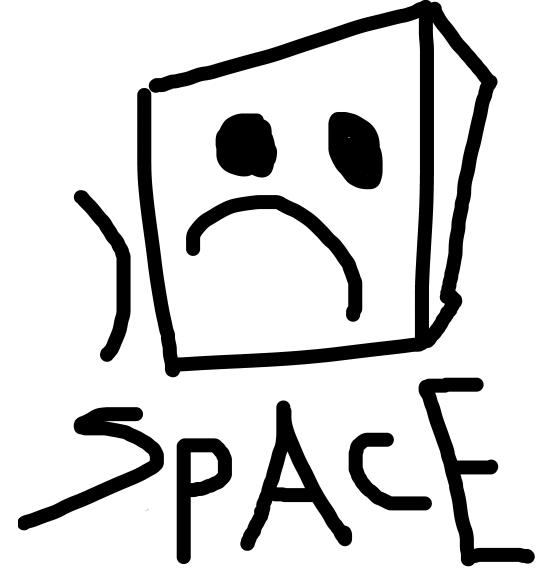


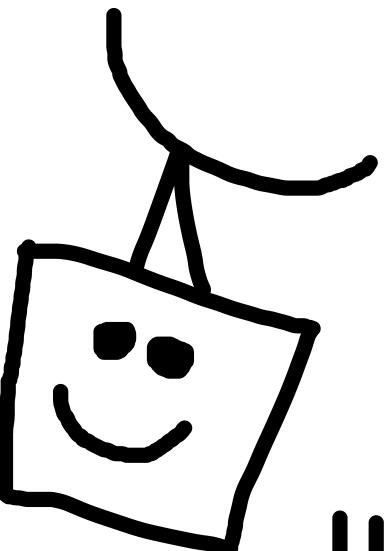
ITAR

AMSAT

$$\varphi^4$$

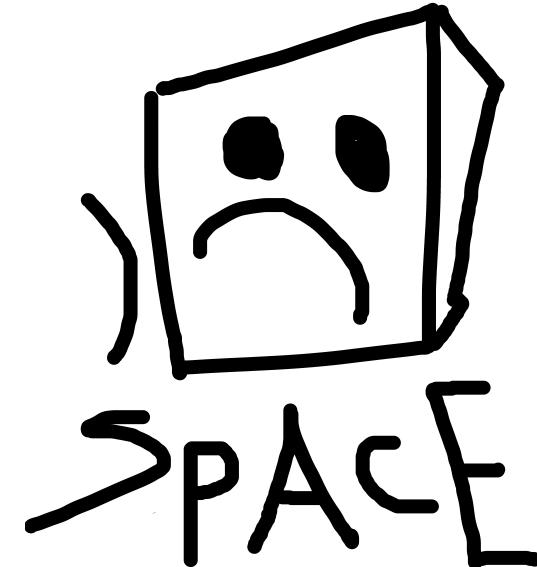
Open  
Source

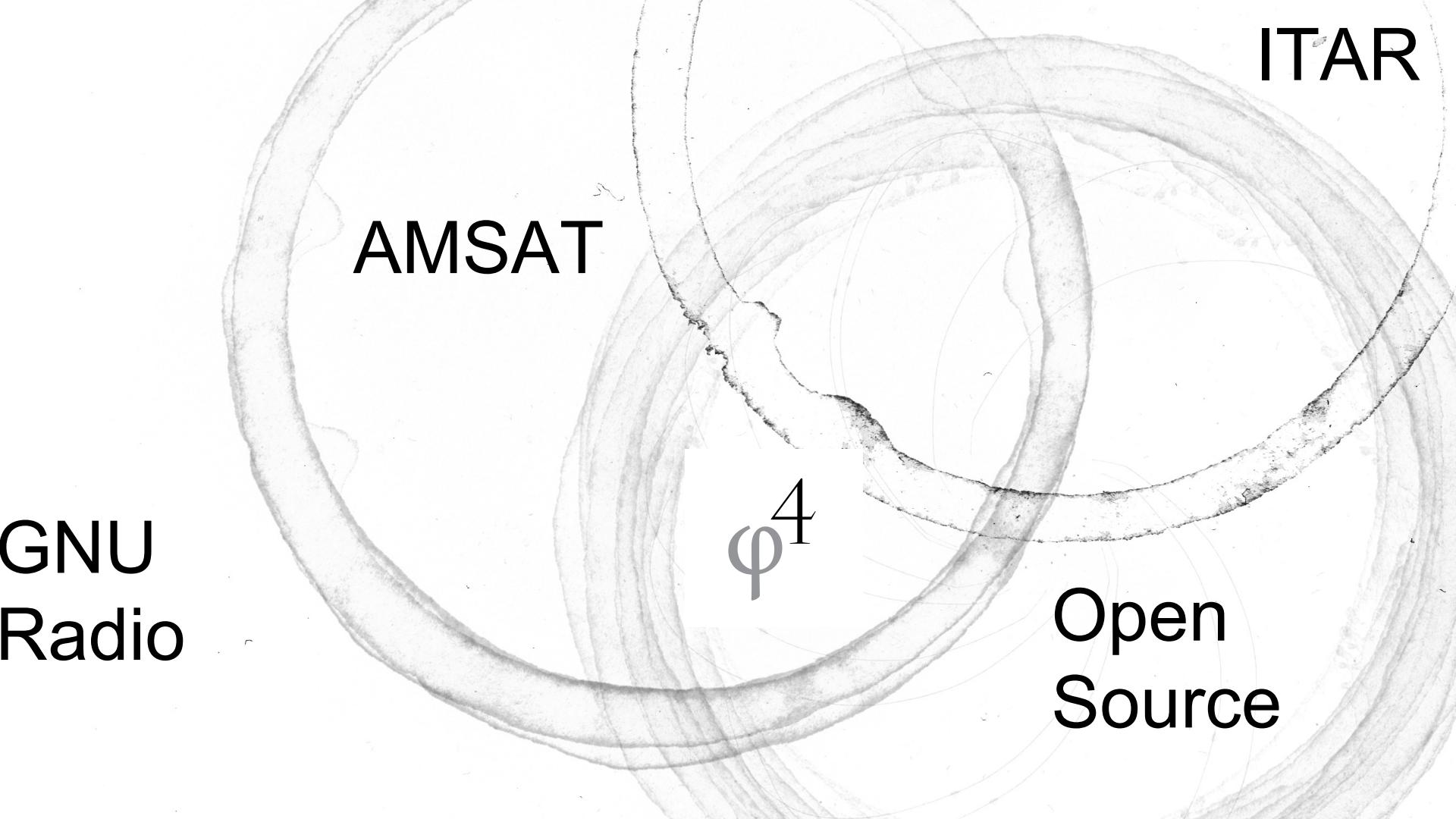




Michelle

Common  
Air  
Interface  
Document





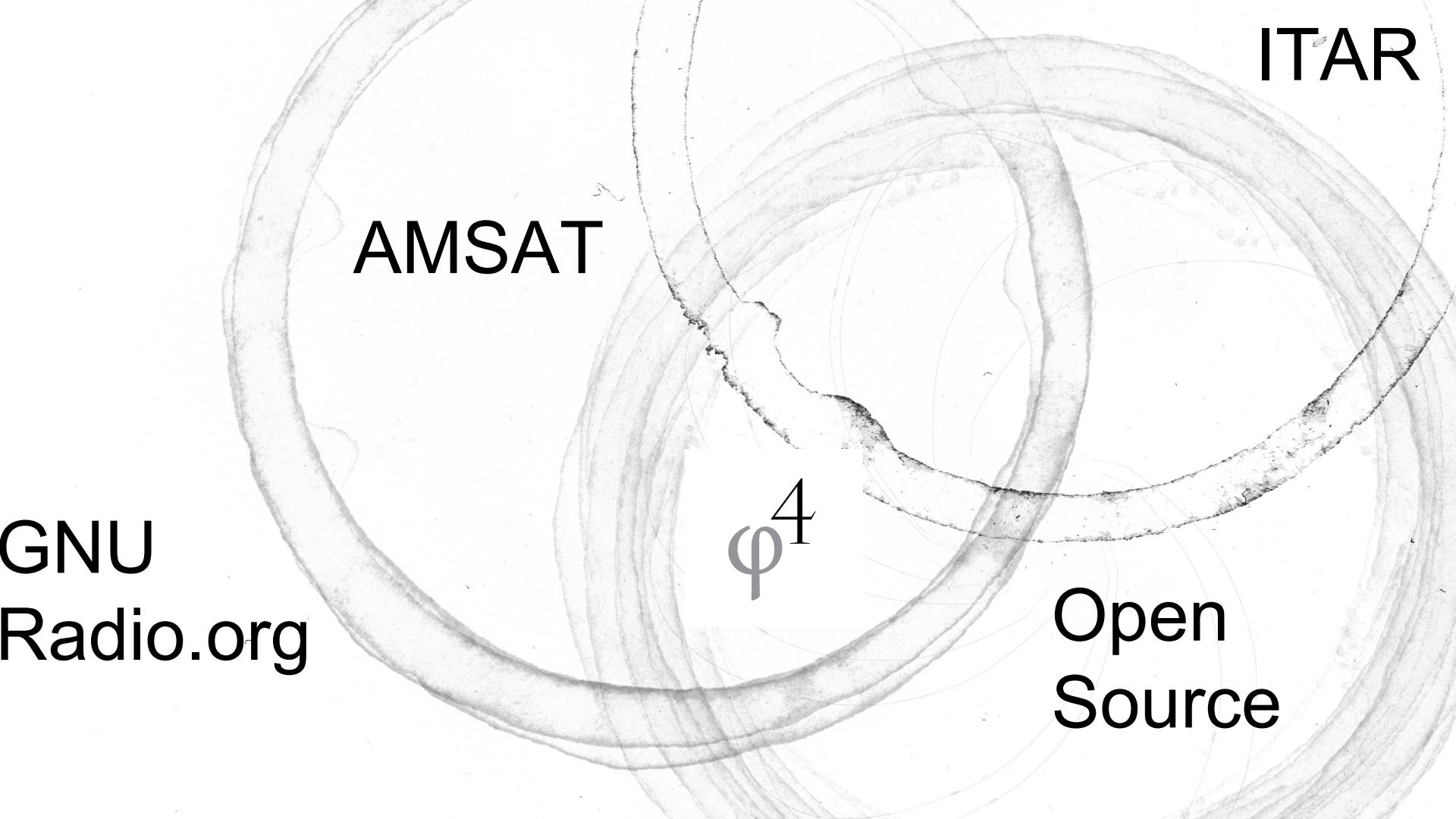
ITAR

AMSAT

$\varphi^4$

GNU  
Radio

Open  
Source



ITAR

AMSAT

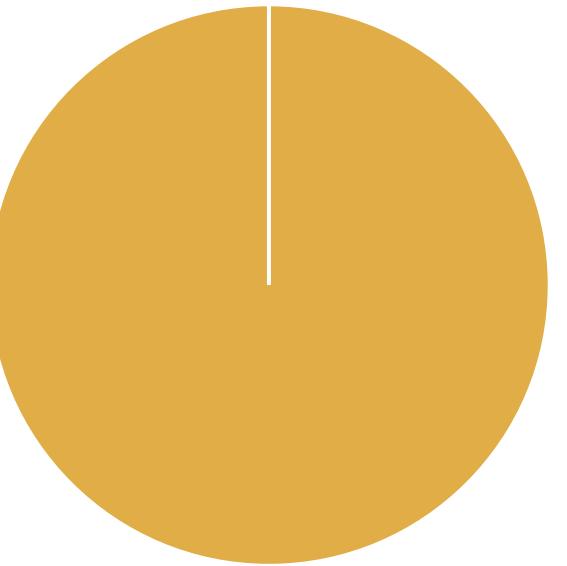
$$\varphi^4$$

GNU  
Radio.org

Open  
Source

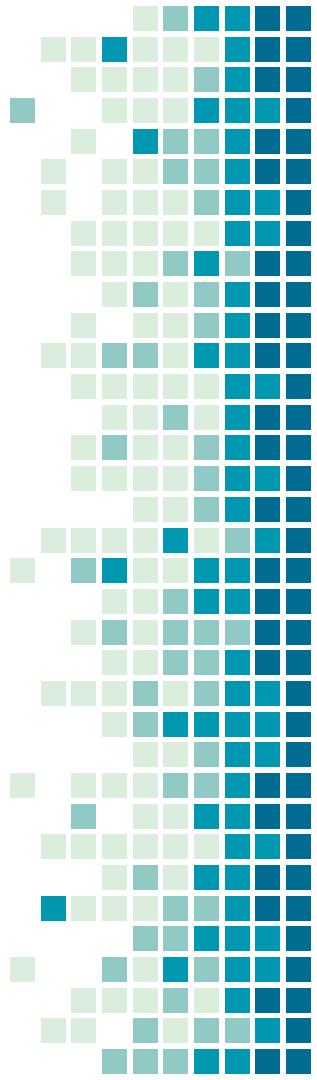
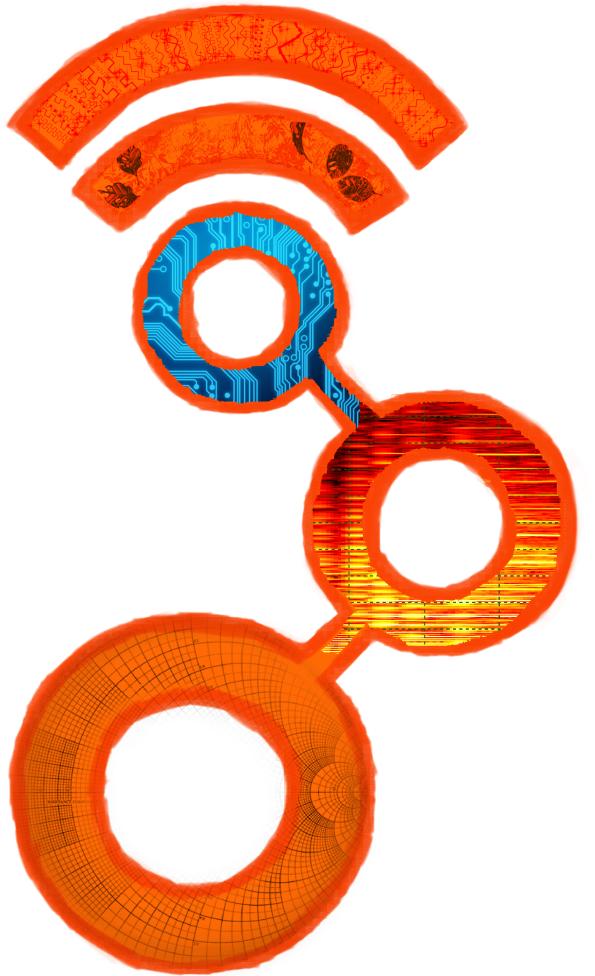
# Challenges of the Venn Lands

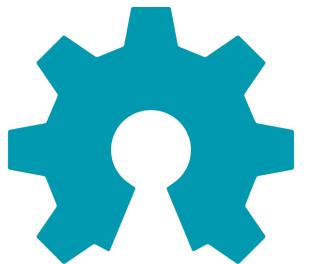
# AMSAT Payload Types



**“Backup Plan”**  
**“Balance”**  
**“Wait for Launch”**

There are two payloads  
in there with “digital  
telemetry under voice”

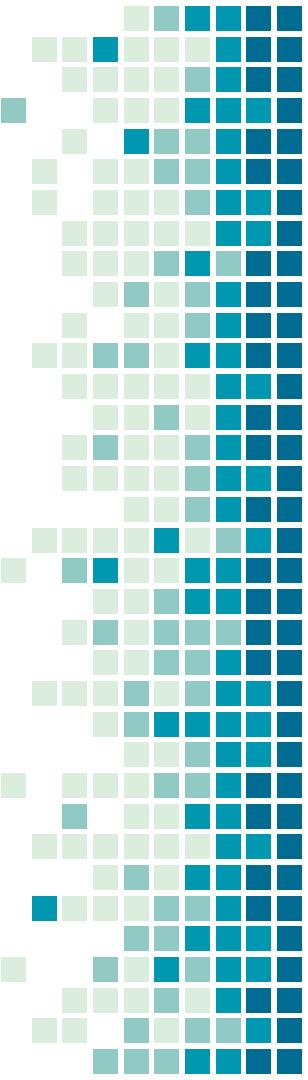




open source  
hardware



**GNU**  
General Public License

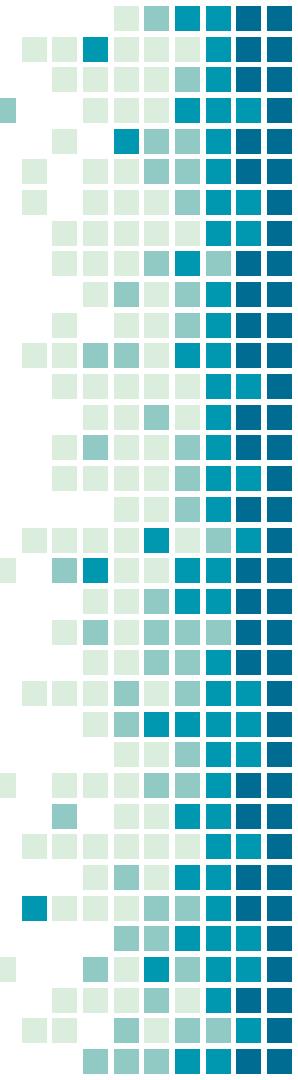




INTERNATIONAL TRAFFIC IN ARMS

**ITAR**

**REGULATIONS COMPLIANT**



# Phase 4 Ground Technical

# Computer Science

*Restored to its proper  
place in the universe.*



MODCODS!

# Modulation

- × How large is the alphabet you are using?
- × How many bits at once can you transmit?
- × DVB-S2 gives you lots of choices!



# Forward Error Correction

- ×DVB-S2 uses a concatenated code consisting of an outer Bose–Chaudhuri–Hocquenghem (BCH) code and an inner low density parity check (LDPC) code.



# G4GUO DVB-S2/S2X

## SDR-Based Demodulator

### for Space Communications

#### Accelerated by NVidia GTX 980 Ti



#### Reasons for project

- 1) Can be optimised for special applications
- 2) No need for an NDA to use it
- 3) Uses readily available hardware
- 4) An exercise in self learning
- 5) Encourage others to investigate use of GPUs
- 6) Architecture not limited to DVB-S2



#### Current Status

Demodulator will decode rates of up to 1 Mbit/s of the more common parts of the DVB-S2 standard. Supports ADALM-PlutoSDR and basic support for LimeSDR.

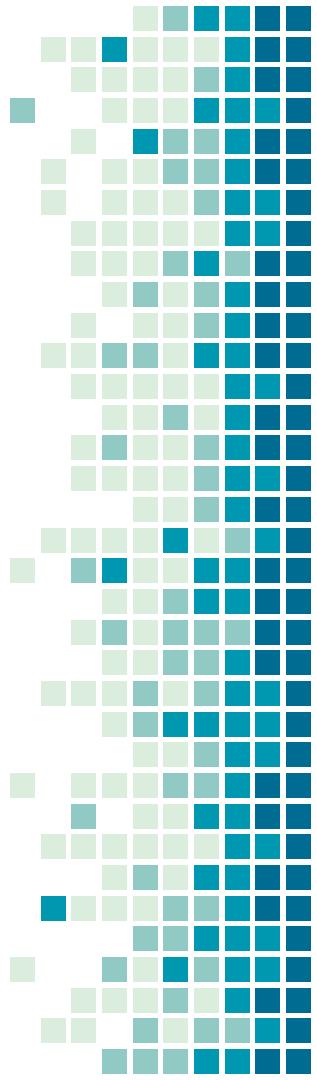
#### Future work

Move LDPC Bitnode and Checknode mapping tables into Texture memory, Texture memory is cached read only memory which has low latency if memory fetches are located close to one another in 2D space.

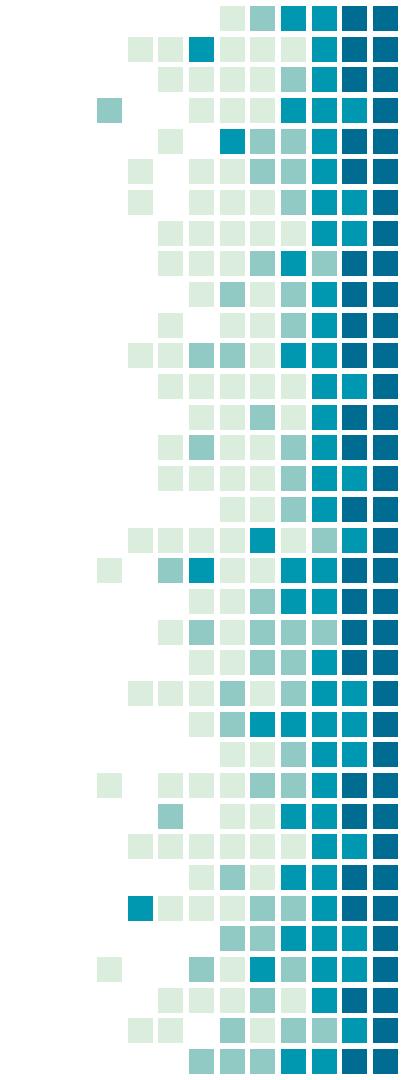
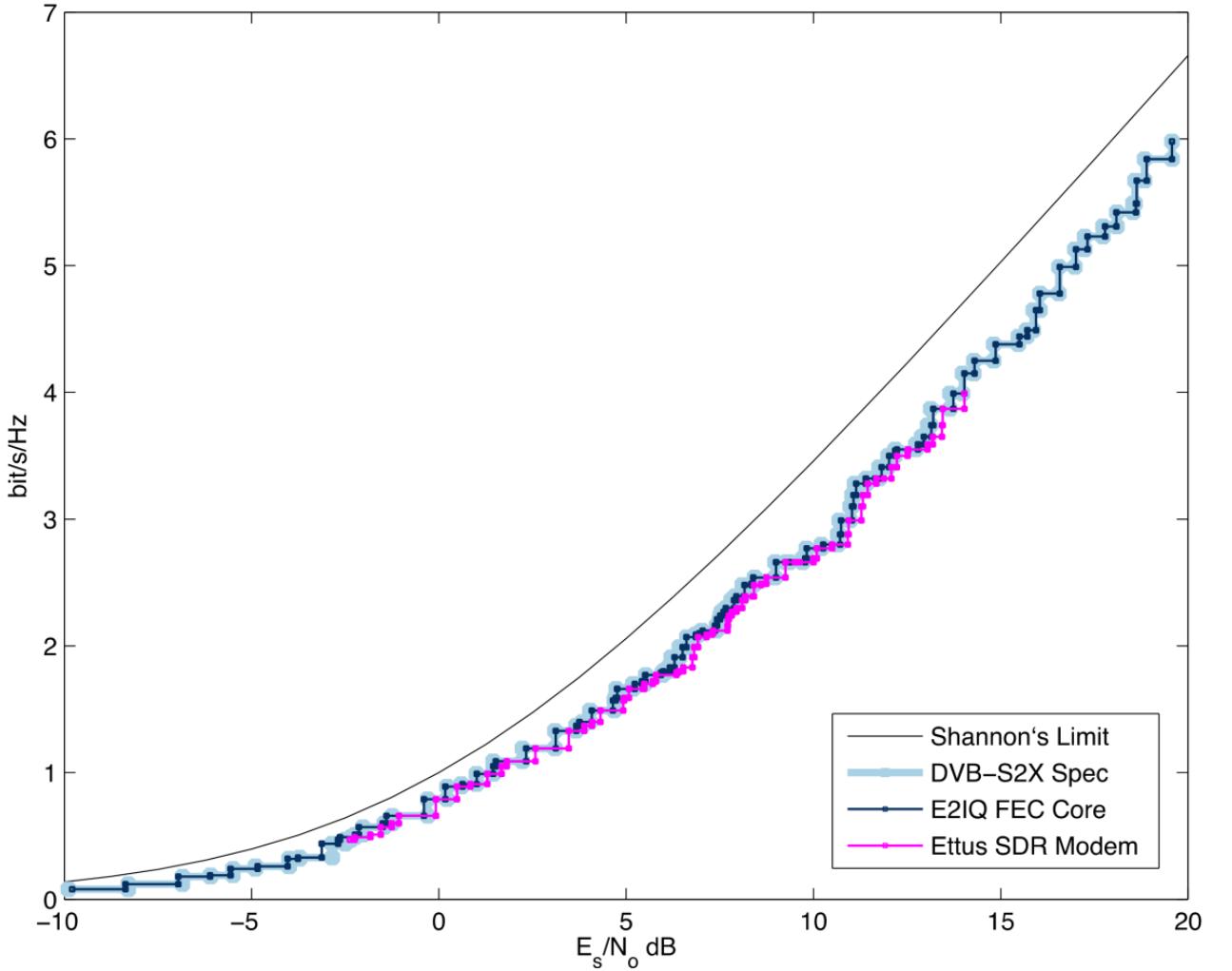
Process multiple frames in parallel, this allows better memory coalescing of bit and check node metrics. Due to the low density nature of LDPC codes efficient memory access is difficult.

Reduce size of metrics, currently 32 bits to further improve memory access performance.

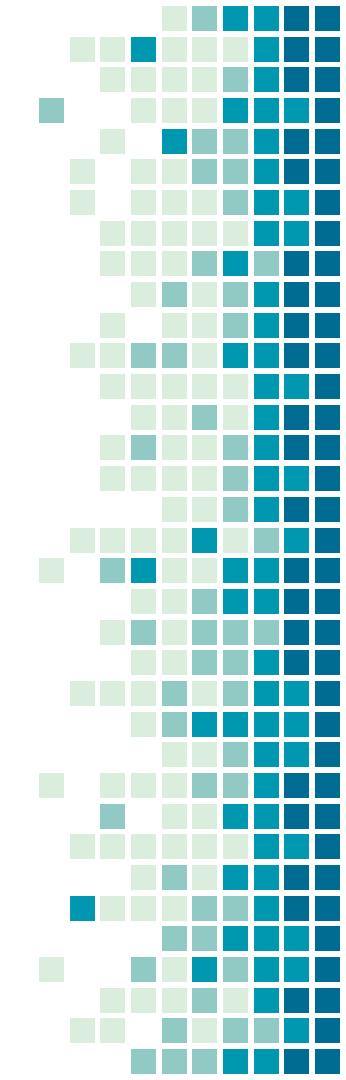
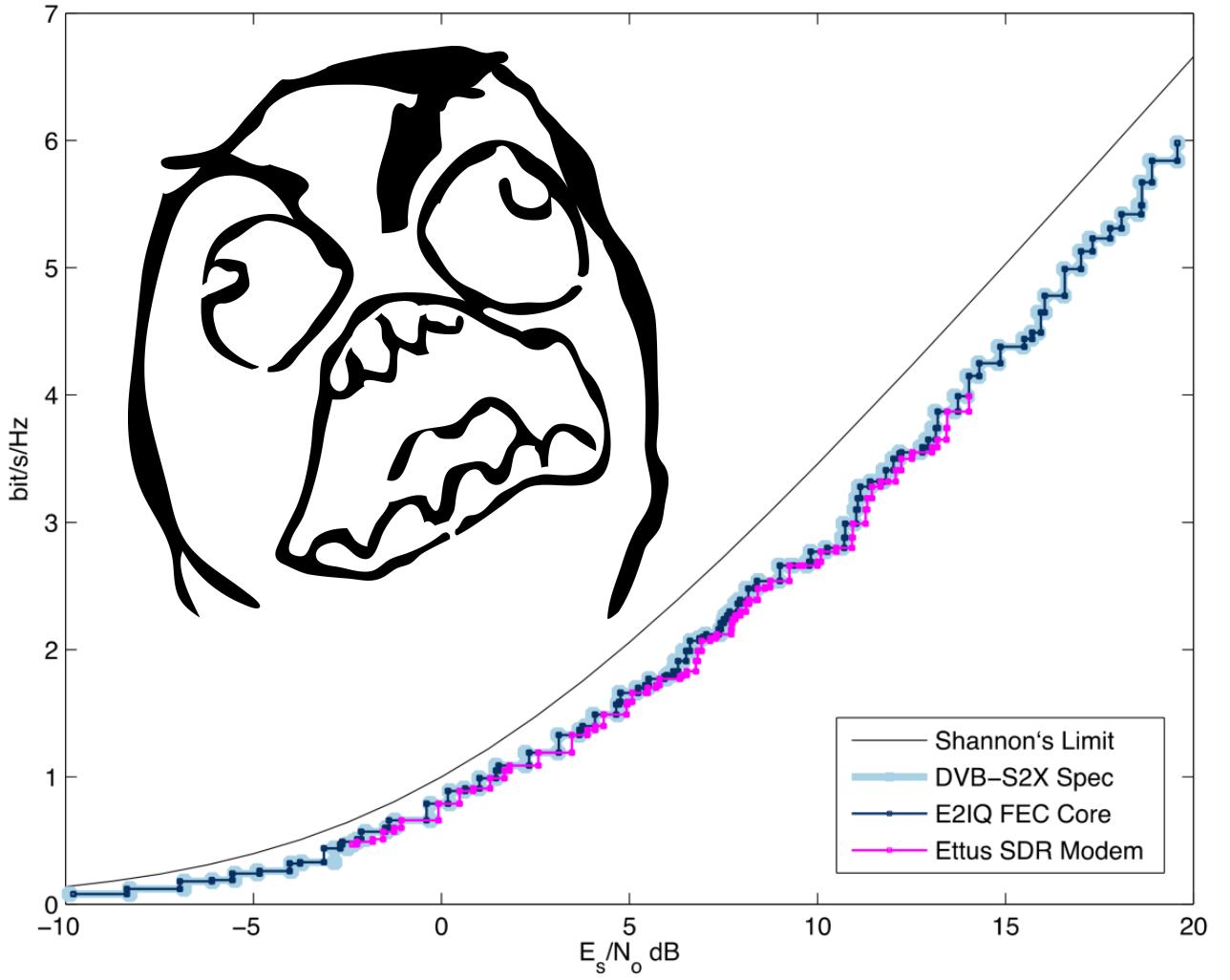
Speed up BCH processing using lookup tables for initial error checking and multiple CPU threads for correction of frames with errors.



# Spectral Efficiency of E2IQ FEC Core and Modem



# Spectral Efficiency of E2IQ FEC Core and Modem

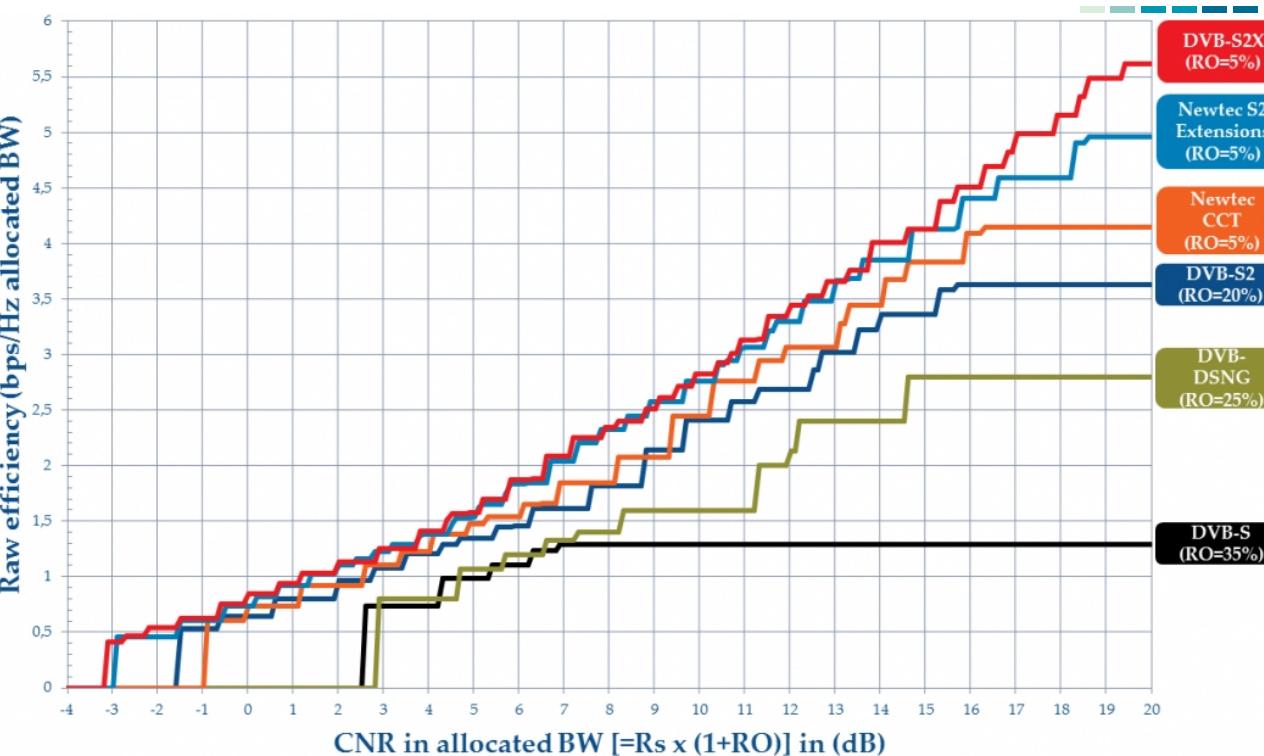


# DVB HISTORY

## DVB-S2X

- 116 MODCODS
- Up to 256APSK 11/15
- 3 framesizes (normal, short, medium)
- Linear and non-Linear
- RO: 5%, 10%, 15%, 20%, 25%, 35%

Backward compatible DVB-S2 mode



Data Rate =  
Symbol Rate \* Code Rate \* Modulation  
Order

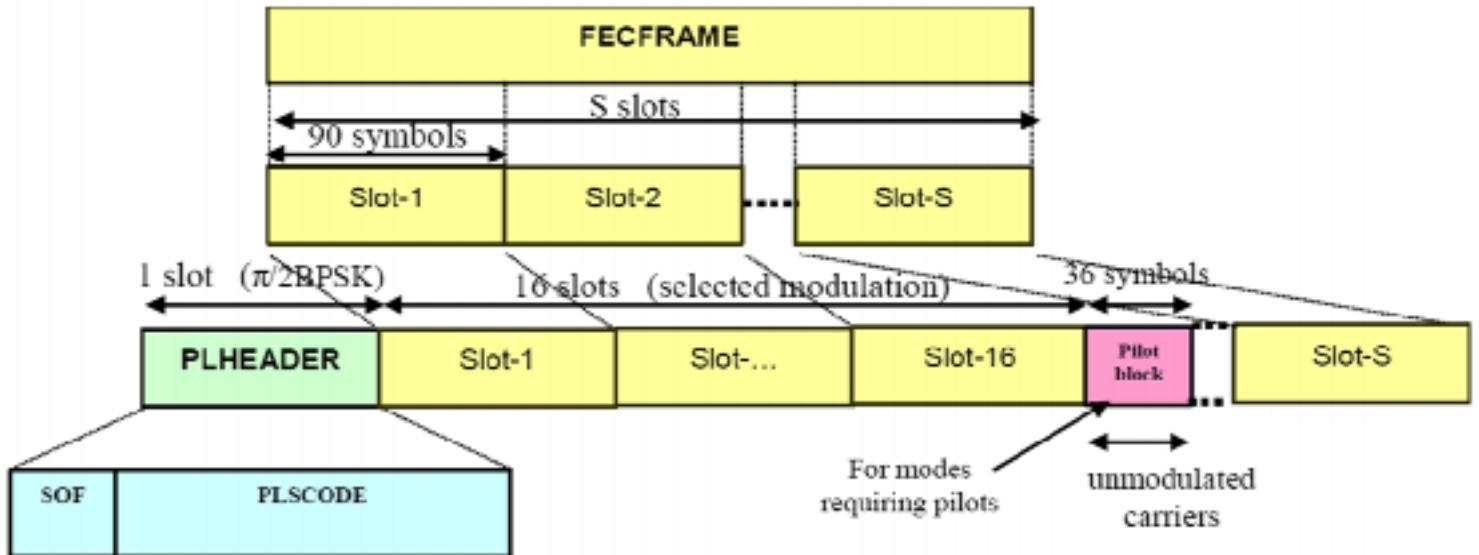


그림 1. DVB-S2 물리 계층 프레임의 구조

# Sponsor $\varphi^4$

- ✗ Ettus Research – multiple USRPs
- ✗ Xilinx – three licenses
- ✗ Ansoft – HFSS
- ✗ Slack – nonprofit discount
- ✗ AMSAT – mailing list, funding

Correlator, Synchronization challenges

Radio interface is HTML5 – no software installs

5GHz RF amplifiers and filters

Dual band feed success!

10GHz receiver chain, clock quality

FPGA coding, GPU coding, GNU Radio coding...

ASIC board that enables DVB-S2X

Art, lots of it!

Telemetry API

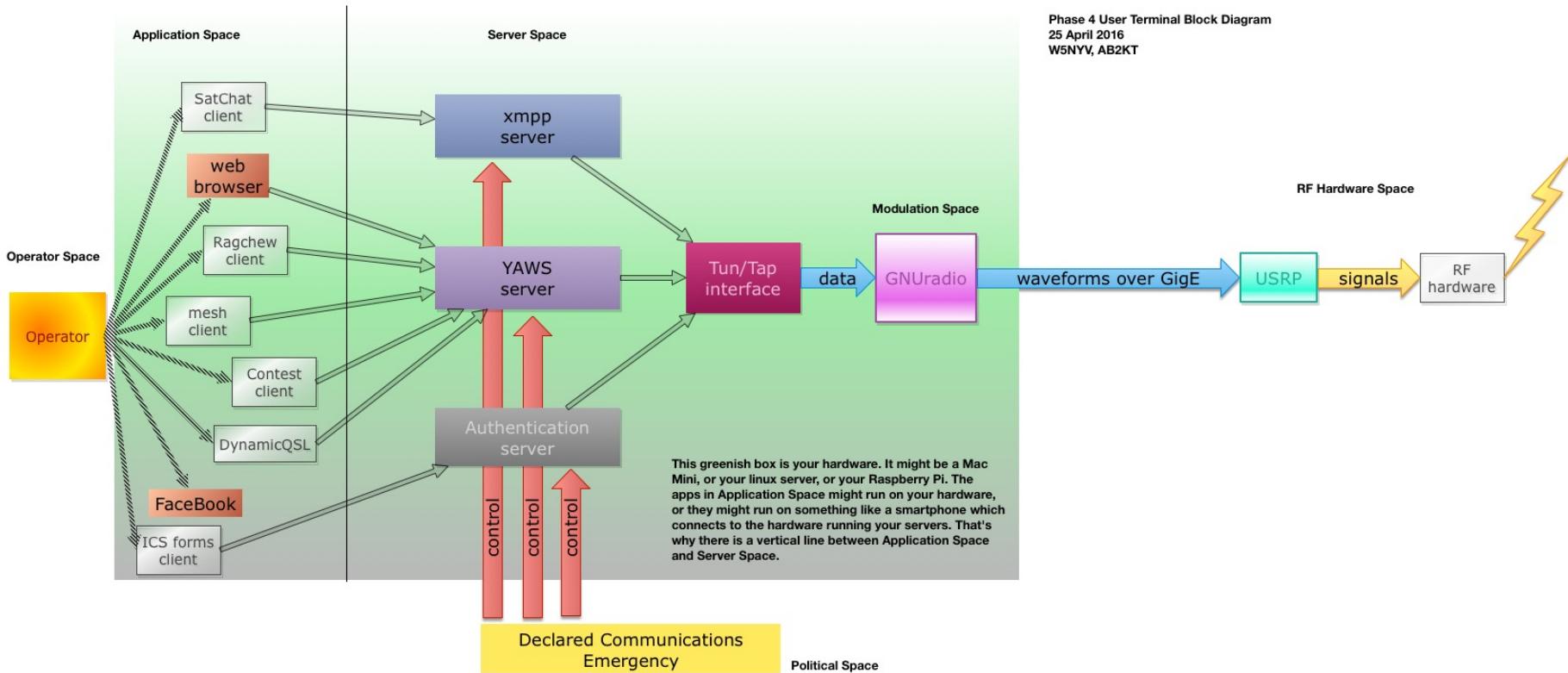
Friendly and accessible, learning-positive team

Join at <https://phase4ground.github.io/>

### Phase 4 User Terminal Block Diagram

25 April 2016

W5NYV, AB2KT





# Questions!