



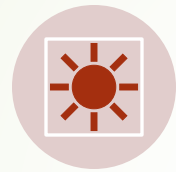
Ham Radio Satellites

Why would anybody want to do that?

Fred Castello – KF4FC



Why?



It is cool



It is technically
challenging



It is operationally
challenging



It is not dependent
on propagation
(largely)



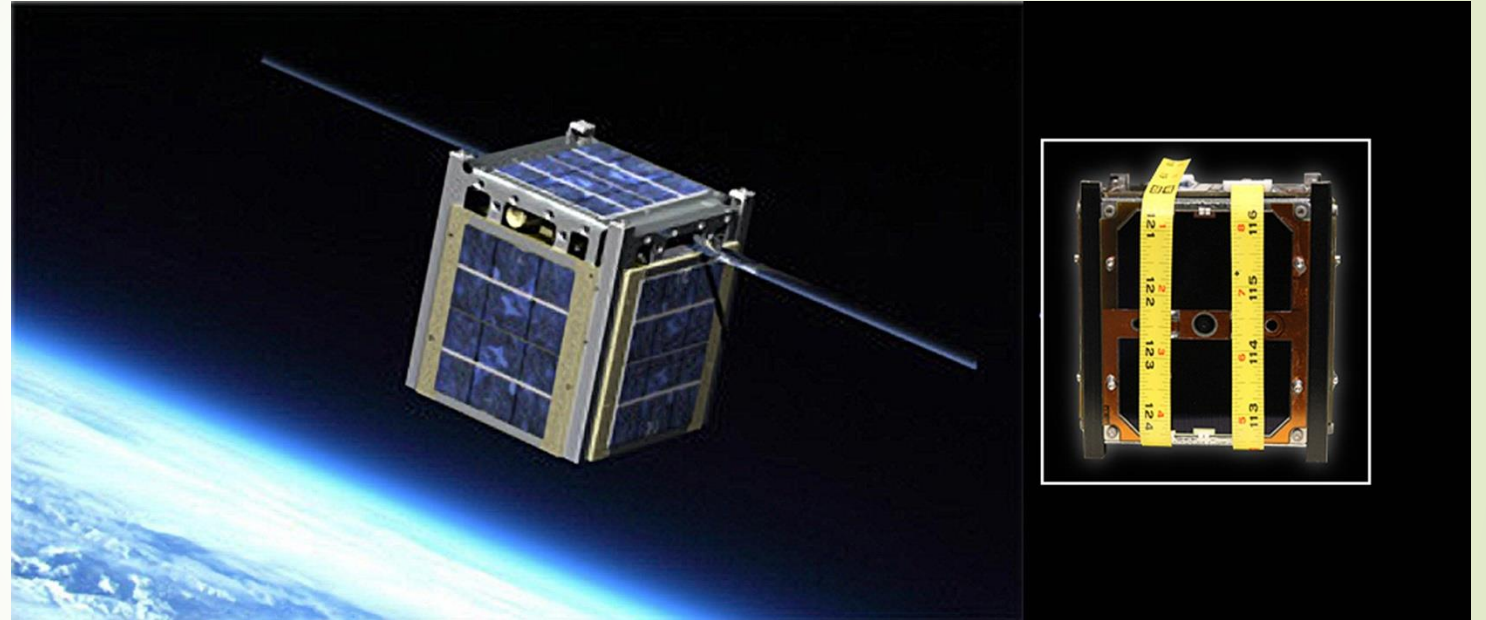
It can be done by
any class of radio
amateur

What Kind Of Satellites Are We Talking About Anyway?

Most are something like this:

$10\text{ cm} * 10\text{ cm} * 10\text{ cm} = 1\text{ unit}$
cubesat

Some are up to 3 unit cubesats
(i.e. 30 cm by 10 cm)





Characteristics of These Satellites (**OSCAR**-Orbiting Satellite Carrying Amateur Radio)

- Low Earth Orbit (LEO): 160-2000 km (100-1200 miles)
 - Typically, smaller satellites. Similar orbit as ISS (International Space Station)
 - Rockets required to get these in orbit are smaller and less expensive
 - Orbital period of about **90 minutes**
 - Low latency
 - Travelling at 17,500 mph
- For perspective, a Geosynchronous Orbit is 35,786 km (22,236 miles)



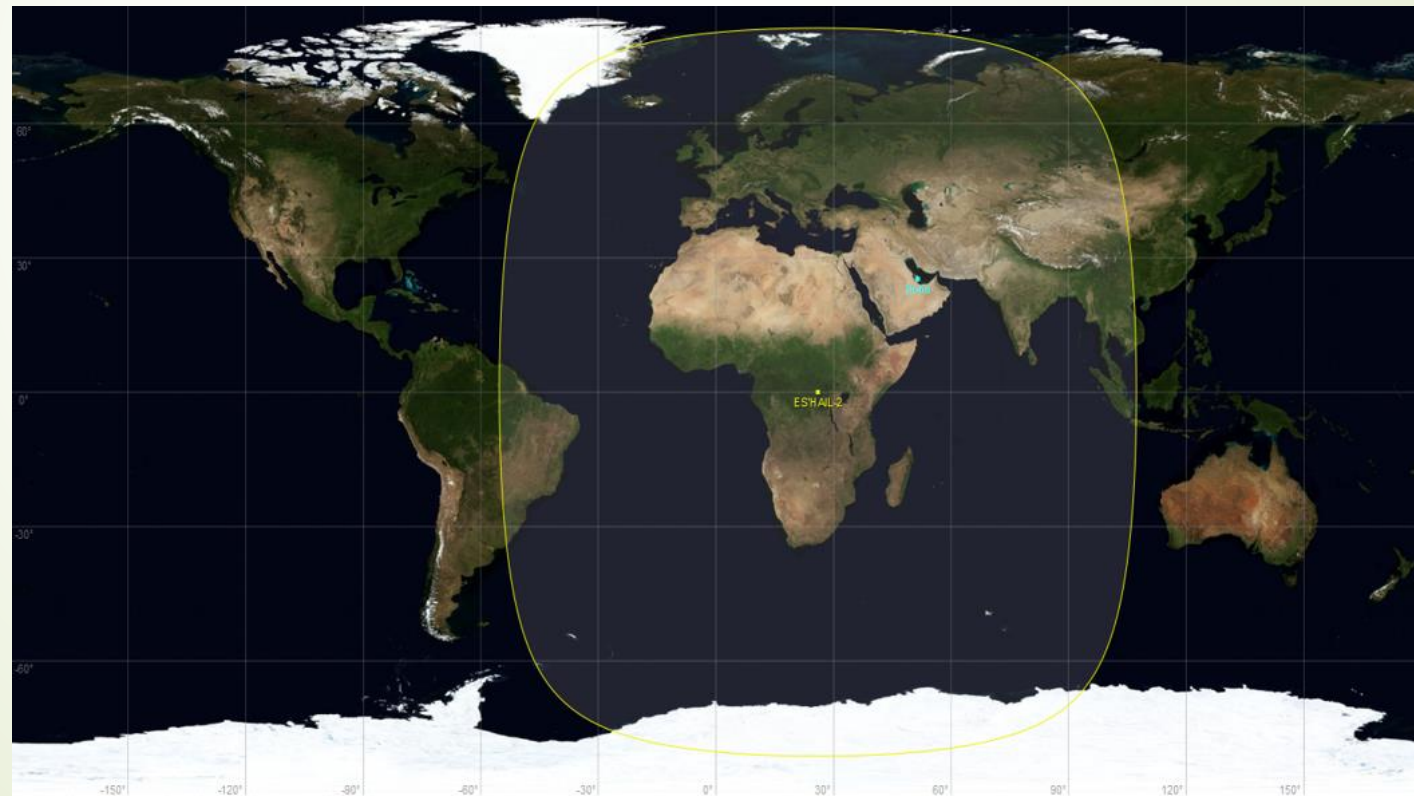
Characteristics of These Satellites (**OSCAR**-Orbiting Satellite Carrying Amateur Radio)

- ▶ Polar Orbit
- ▶ Uplink Frequency and Downlink Frequency are Different
 - ▶ Example: 2 meters and 70 cms
- ▶ Low Power
- ▶ Line of Sight
 - ▶ Because line of sight, the low power of the satellites (i.e 250 milliwatts – 5 watts) can be amazingly effective
- ▶ At the time of this writing (June 2024) there are about **13 amateur radio satellites** that licensed operators can use (Tech and above)

GEOSYNCHRONOUS ORBIT

Es'hail-2: Uplink 2.4 GHz Downlink 10.4 GHz

Developed as a joint effort between the Qatar Amateur Radio Society (QARS),
Es'HailSat, and AMSAT-DL



How Do They Get There?



“Catch a Ride” with other rocket payloads



Placed in orbit by ISS

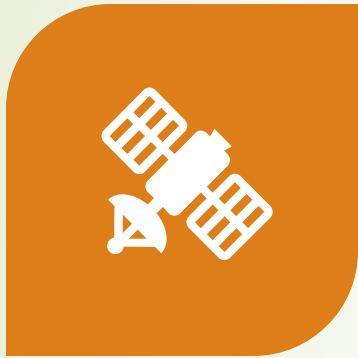
Consideration to pay for launch occasionally!



Operating Modes

- ▶ Voice
 - ▶ FM (acting as repeaters)
 - ▶ SSB/CW (linear transponders: **in** on one range of frequencies and **out** on a different range of frequencies in a different band) Example: in on 2 meters and out on 70 cm (sometimes inverted: i.e. high on band in becomes low on band out **AND** transmit in LSB and receive in USB)
- ▶ CW
- ▶ Data
 - ▶ Packet (store and forward)
 - ▶ Telemetry
 - ▶ APRS: **A**utomatic **P**acket **R**eporting **S**ystem (ISS)

Operational Issues



ACQUIRING AND
TRACKING THE SATELLITE



DOPPLER SHIFT



EQUIPMENT OPTIONS



Acquiring and Tracking the Satellite Software

- ▶ Linux: Gpredict, SatTrack
- ▶ Windows: Nova, HRD, Orbitron, **SatPC32 (this is what I use)**
- ▶ Mac: MacDoppler
- ▶ Android: AmsatDroid, Heavens Above
- ▶ iPhone: SatSat, Satellites Space Tracker App



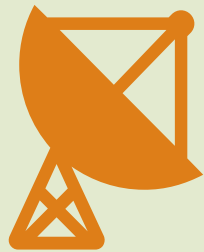
Doppler Shift

- ▶ “The change in frequency or wavelength of a wave when an observer and the wave source are in motion relative to each other”
 - ▶ When the satellite is **approaching** you, you will experience an **increase in frequency** (i.e. decrease in wavelength)
 - ▶ When the satellite is **moving away** from you, you will experience a **decrease in frequency** (i.e. increase in wavelength)

Example of Programming a Handheld

AO-91 Doppler Shift Correction		
Memory	TX Frequency (w/ 67 Hz Tone)	RX Frequency
Acquisition of Signal (AOS)	435.240 MHz	145.960 MHz
Approaching	435.245 MHz	145.960 MHz
Time of Closest Approach (TCA)	435.250 MHz	145.960 MHz
Departing	435.255 MHz	145.960 MHz
Loss of Signal (LOS)	435.260 MHz	145.960 MHz

What Type of Radios?



For the FM only Birds

Dual Band FM transceiver with crossband transmit/receive ability **or** separate 2 meter and 70 cm FM transceivers are an option



For Linear Transponders

SSB and/or CW transceivers. One needs the ability to transmit on one frequency (i.e band) and **receive at the same time on another frequency** (band)



-21% \$22⁰⁰

List Price: \$27.99 ⓘ

✓prime

FREE Returns ▾

Get \$125 off: Pay \$0.00 upon approval for the [Amazon Business Prime Card](#). Terms apply.

Pattern Name: **Radio**

Product details

Brand	BAOFENG
Color	Black
Number of Channels	128
Number of Batteries	1 Lithium Metal batteries required. (included)

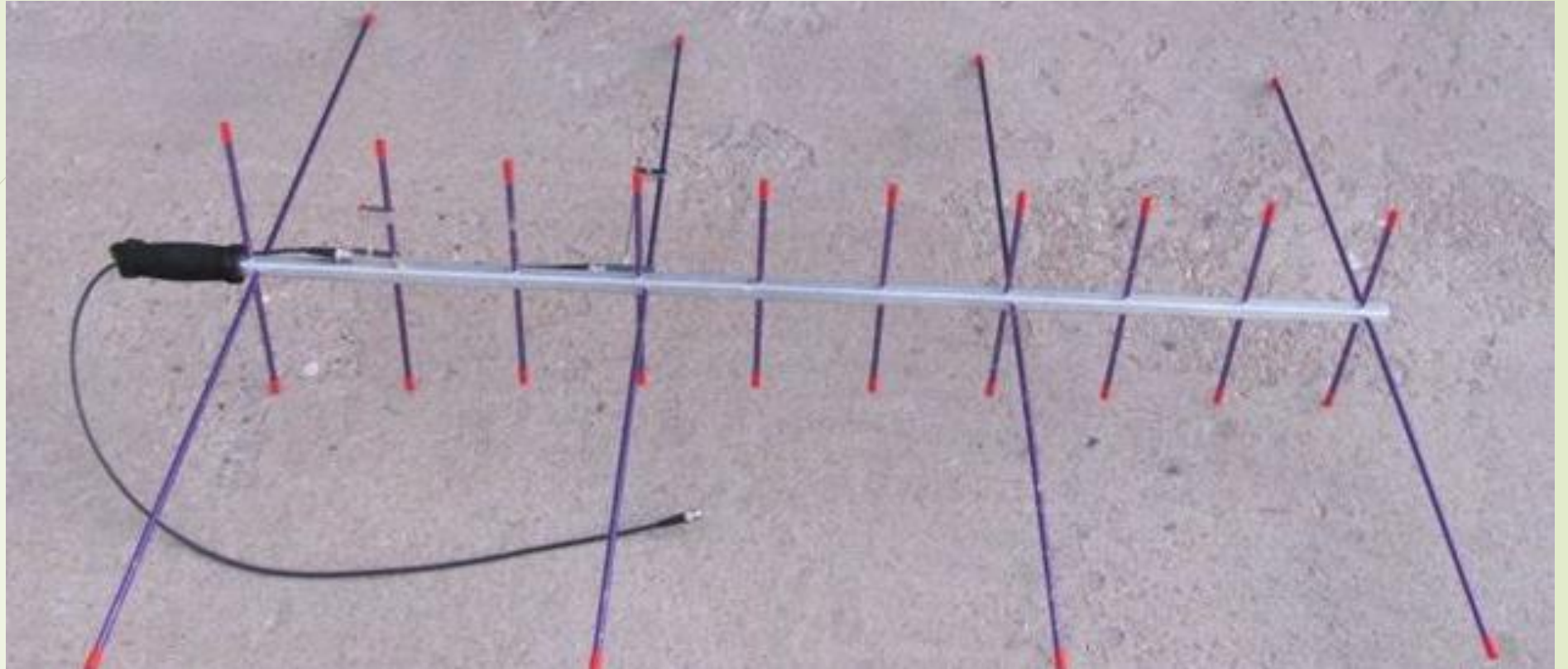
Baofeng UV-5R Dual Band



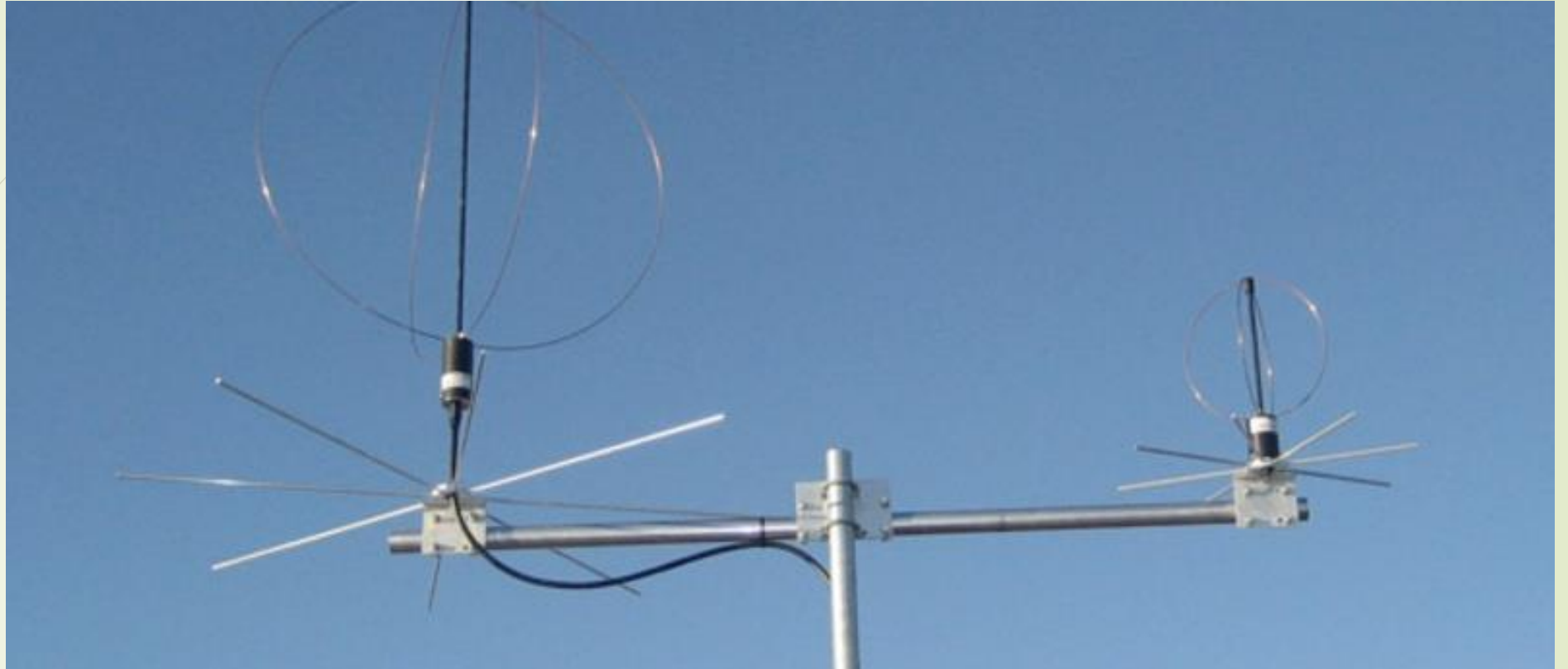
Kenwood TS-790A (What I Use)-released in 1990



Icom IC-9700- An Exceptional Satellite Radio



Arrow Satellite Antenna with Duplexer (built into handle)
(10 watts max)



Egg Beater Antennas

No Rotors required Limited gain

KF4FC Satellite Antennas

- ▀ 2 meters and 70 cm
- ▀ Preamps at base of antennas
- ▀ Circularly polarized
- ▀ Switchable between Right and Left hand polarization
- ▀ Azimuth and Elevation rotors





Box at Base of Antennas

2 meter and 70 cm preamps

Duplexer- significantly reduces
transmit overload of receiver



Helps a LOT to
Record QSO's

I use a Sony ICD-PX370 Digital
Recorder





Sample FM “Repeater” Satellite QSO

- Rapid exchange of information
- Typical QSO involves Call and grid square
- Other people are waiting for the bird



movavi

This video was made with
Screen Recorder

WD9EWK

DM43 - Patrick, Scottsdale, AZ



KF4FC Example of QSO on Linear Transponder

- Wide band of available frequencies
- USB up, LSB down (inverting transponder)
- Notice that I can hear myself talking
- This is very important because of the dual band nature of the technology and the doppler shift
- A bit more relaxed than the FM satellites (more fun for me)



KF4FC QSO 4/18/22

- **Satellite**
 - **RS-44**





Satellite Telemetry

- ▶ Allows users to receive immediate real time information about the spacecraft and share that information with the entity that launched and is maintaining the satellite
- ▶ In the cases that I share with you, the software was already written by the launching entity
- ▶ Really fairly easy to do
- ▶ In both cases I used an RTL-SDR
- ▶ Remember, I have preamps at the base of the antenna for receiving these signals (helps a lot)

FULL 2-YEAR WARRANTY AGAINST MANUFACTURING FAULTS
EMAIL & FORUM SUPPORT
SUPPORTS THE BLOG FOR NEW CONTENT, TUTORIALS AND PRODUCTS!

GENUINE GUARANTEE:
BE WARY OF INFERIOR
RTL-SDR BLOG V3 COUNTERFEITS!

RTL
SDR
BLOG



Original RTL-SDR Blog V3

- Rounded enclosure
- Full website URL written on body
- Two diagonally offset screws on each side
- Newer units have logo on the back
- Green PCB with thermal pad on bottom
- NSY production QC sticker on back
- Newer units say R860 instead of R820T



\$29.95 on Amazon-There ARE Fakes



Satellite Amsat Oscar-91 (Fox1B)

- ▶ FM repeater satellite
- ▶ Launched 2017
- ▶ Telemetry is “Data Under Voice” (DUV)
- ▶ Low frequency audio transmissions that is occurring at the same time amateur QSO's are taking place
- ▶ Many ham radio receivers filter out this low frequency and thus are not suitable for use
- ▶ That is why I use the RTL-SDR
- ▶ You will hear both the low frequency telemetry and the voice QSO's

Stop

DAX Audio RX 1 (FlexRadio Systems DAX Audio)

48000

AF IQ

AO-85: Tracked via SATPC32

Fox-1Cliff: Not Tracked

Fox-1D: Not Tracked

Fox-1E: Not Tracked

AO-91: Not Tracked

Audio Options

View Filtered Audio

Monitor Filtered Audio

Squelch when no telemetry

Data Under Voice (DUV) Filter

Raised Cosine

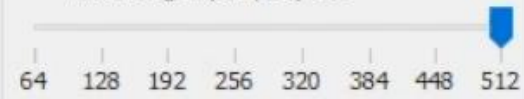
Windowed Sinc

Matched

Cutoff frequency (Hz) 200.0



Filter Length (samples) 512

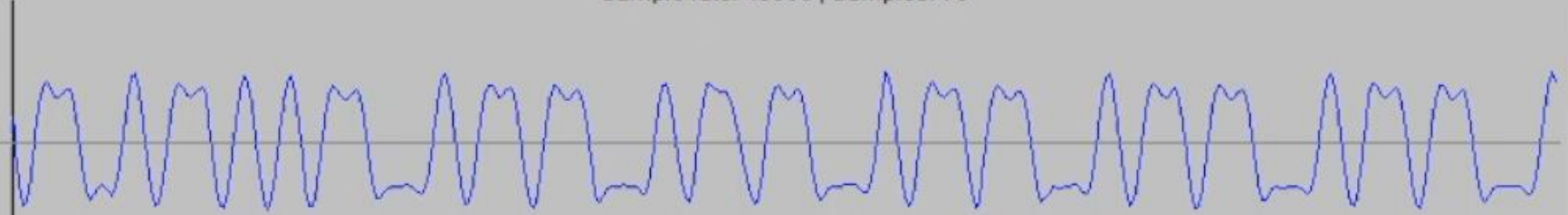


Output

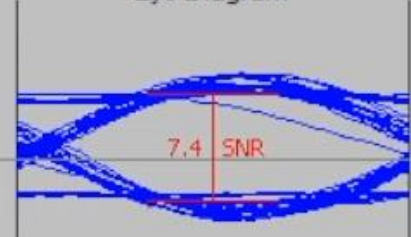
Silence Speaker

Speakers (Realtek High Definition Audio)

Sample rate: 48000 | Samples: 70



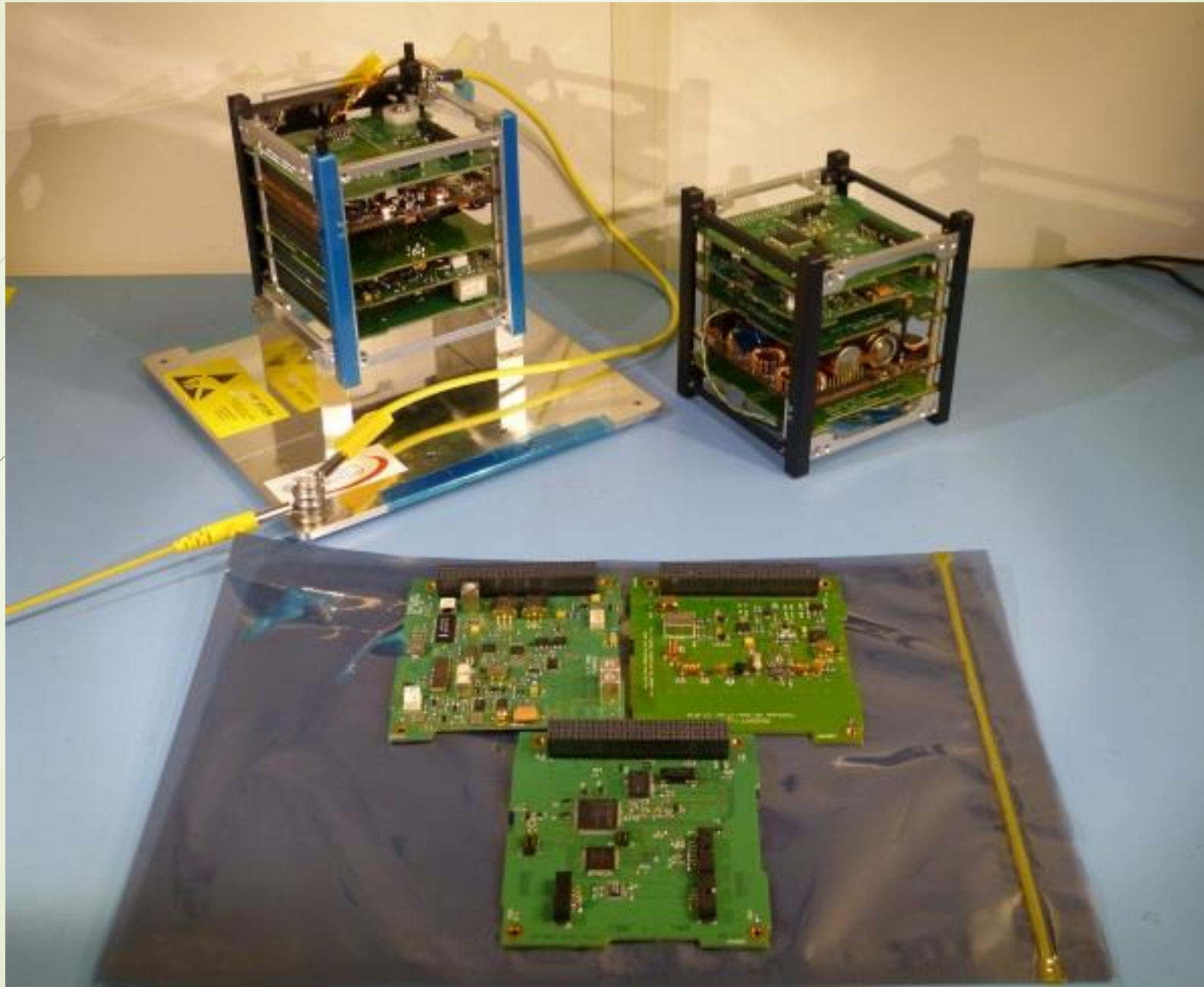
Eye Diagram

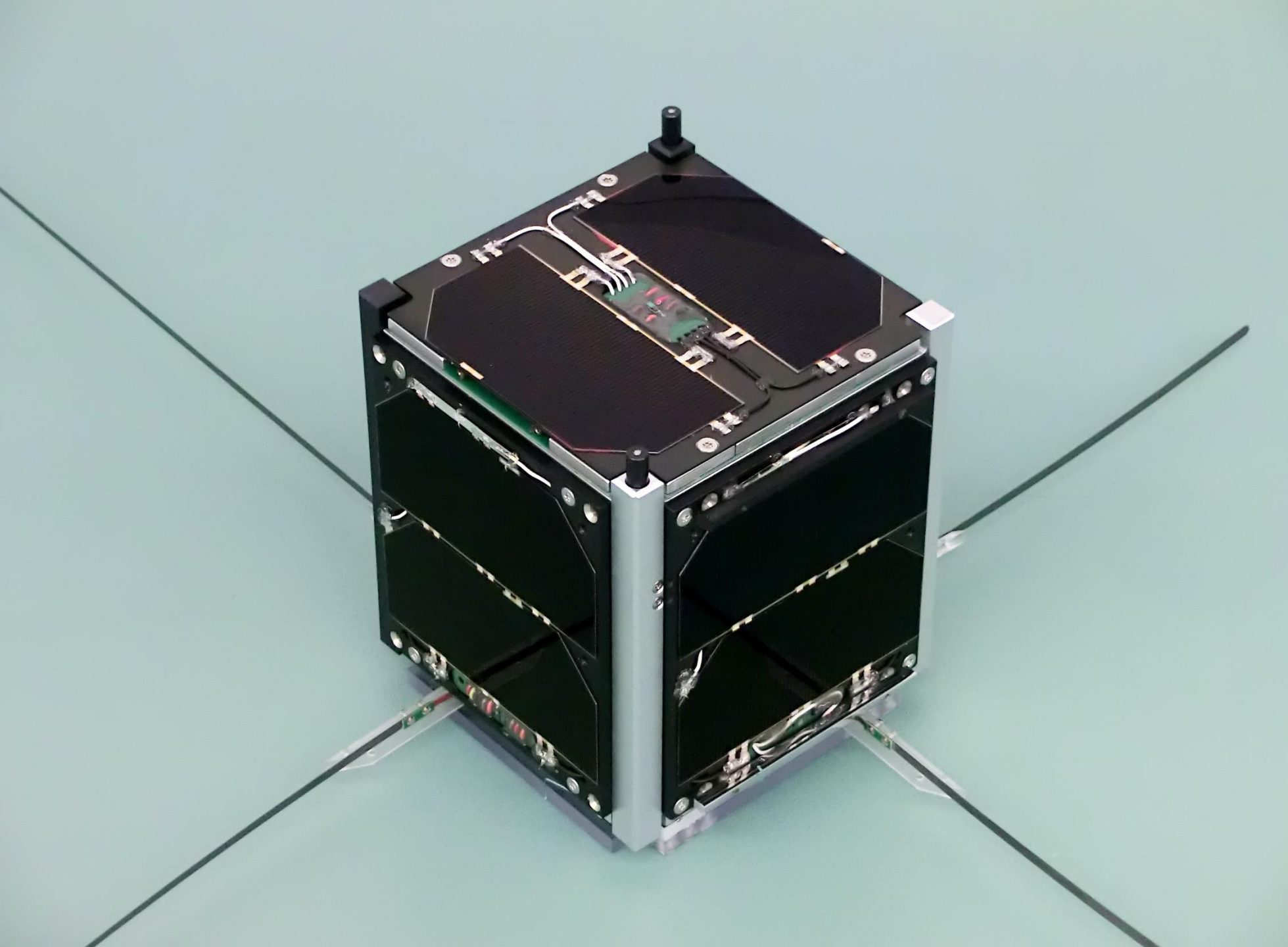




FUNcube-1 Amsat Oscar 73

- CW/SSB Linear Transponder
- Telemetry aimed at schools to decode and report back
- Launched November 21st 2013
- This was recorded on Thanksgiving, 2017









References

- ▶ I want to thank **Tamir Rosenberg N6JJ** from whom I shamelessly stole some slide contents
- ▶ Sample handheld satellite pass with 3 contacts
 - ▶ <https://youtu.be/HBiF8S5cLqE>



Thank You For Your Attention

MARA Club Meeting- 6/6/2024



Questions/Comments?
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fredcastello@gmail.com