Signals in Space: How, Where & What

Presented by Steve Bossert,
exclusively for TCF2023

Today we will cover…….

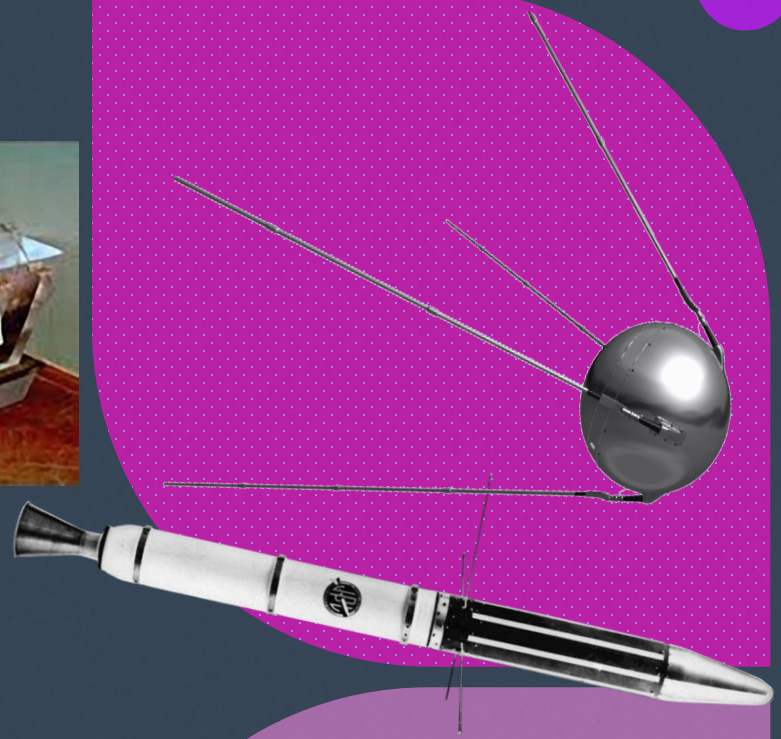
Hi, my name is Steve Bossert. I think there is a biography of me in the TCF pamphlet. My amateur radio callsign is K2GOG and my email is K2GOG@HVDN.ORG if you would like a copy of this presentation.

- ✓ Brief history of PAST "man made" signals from space!!
- ✓ Where in the radio spectrum to find these signals TODAY….
- ✓ How to find them…..
- ✓ And what you can do once you find them!

Brief History of "Man Made" Radio Signals from "Space"

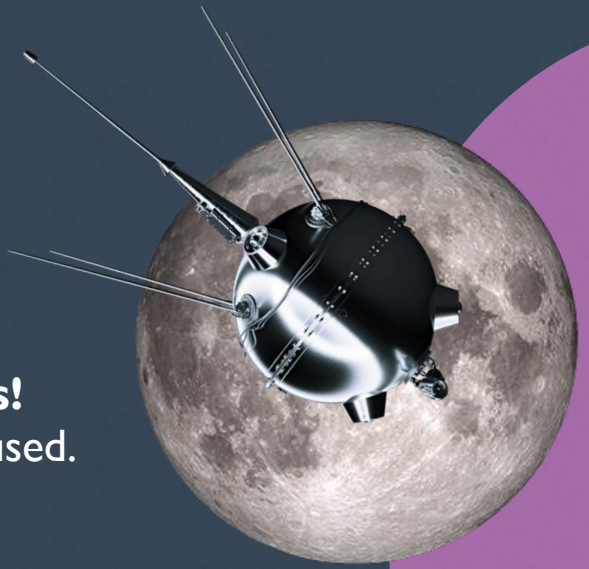
- **1946** – January – 1st "official" signals received back from the Moon
  - "Experimentation" in 1943 from Germany, but 3 years later…..
  - Confirmed signals in 1946…. and from New Jersey!!
  - More on this in Al Katz's "EME" presentation after this!!

- **1957** - October – Sputnik-1 – 22 days in LEO orbit
  - Transmitted at 20.005 MHz and 40.002 MHz
  - Frequencies chosen for atmospheric reasons



- **1957** – November – Sputnik-2 – 162 days in LEO orbit
  - 2nd satellite + canine "Laika" passenger + advanced telemetry

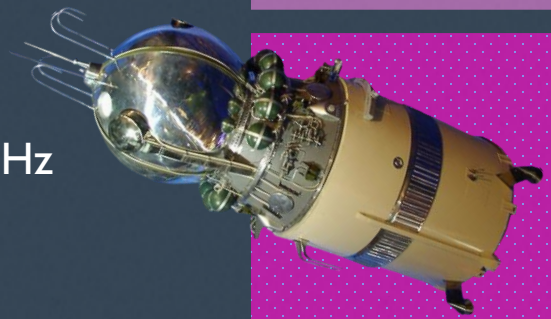
- **1958** – January – Explorer 1 – 111 days in LEO orbit
  - 3rd satellite. Transmitted at 108.0 MHz and 108.03 MHz



- **1958** – March – Vanguard 1 – Still in orbit!!!
  - 4th and oldest still in orbit. Expected to decay another 190 years?
  - No longer transmitting on 108.0 MHz and 108.03 MHz.

- **1959 – January – Lunik 1 – Stuck on the Moon after 62 hours!**
  - 5th man made object in space. 19.993 MHz, 183 MHz, 102 MHz used.
  - Released a sodium cloud to help spot it. Looked like a comet!

Brief History of "Man Made" Radio Signals from "Space"

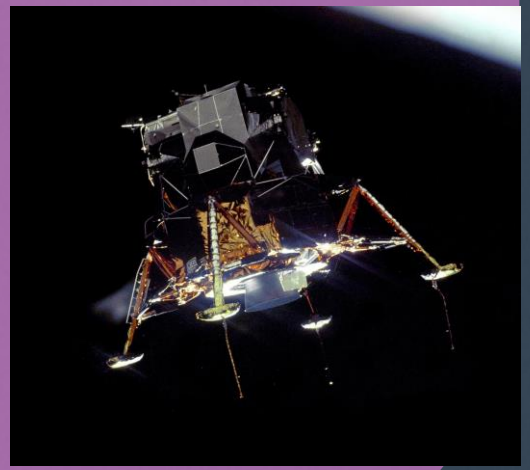


- **1961** – April – 1st human sent into orbit via Vostok 1
  - Poyekhali!!! Yuri Gagarin was his name and sounded like….
  - 143.625 MHz and for many missions since. Also 9.019, 20.006, 19.995 MHz
  - Audio, telemetry and VIDEO transmitted

- **1961-1962** – May, July & August– Shepard, Grissom, Titov, Glenn next into space
  - Freedom 7, Liberty Bell 7 did not orbit. Friendship 7 first to orbit for US.
  - Vostok 2 circled Earth 17 times
  - US develops global ground station footprint. Not needing HF as much anymore.

- **1950's Summary**
  - 14 satellites successfully placed into orbit from USA and Soviet Union in 3 years.
  - Even more firsts and advancement in communications, but not enough time for that today.

- **1960's Summary (Excluding Planetary Landing Related)**
  - 42 satellites successfully into orbit from USA, USSR, UK (Ariel 1), Canada (Alouette 1), Italy (San Marco 1), France (Asterix), Australia (WRESAT), W. Germany (Azur). 1st Commercial communications satellite INTELSAT-1 (April 1965)



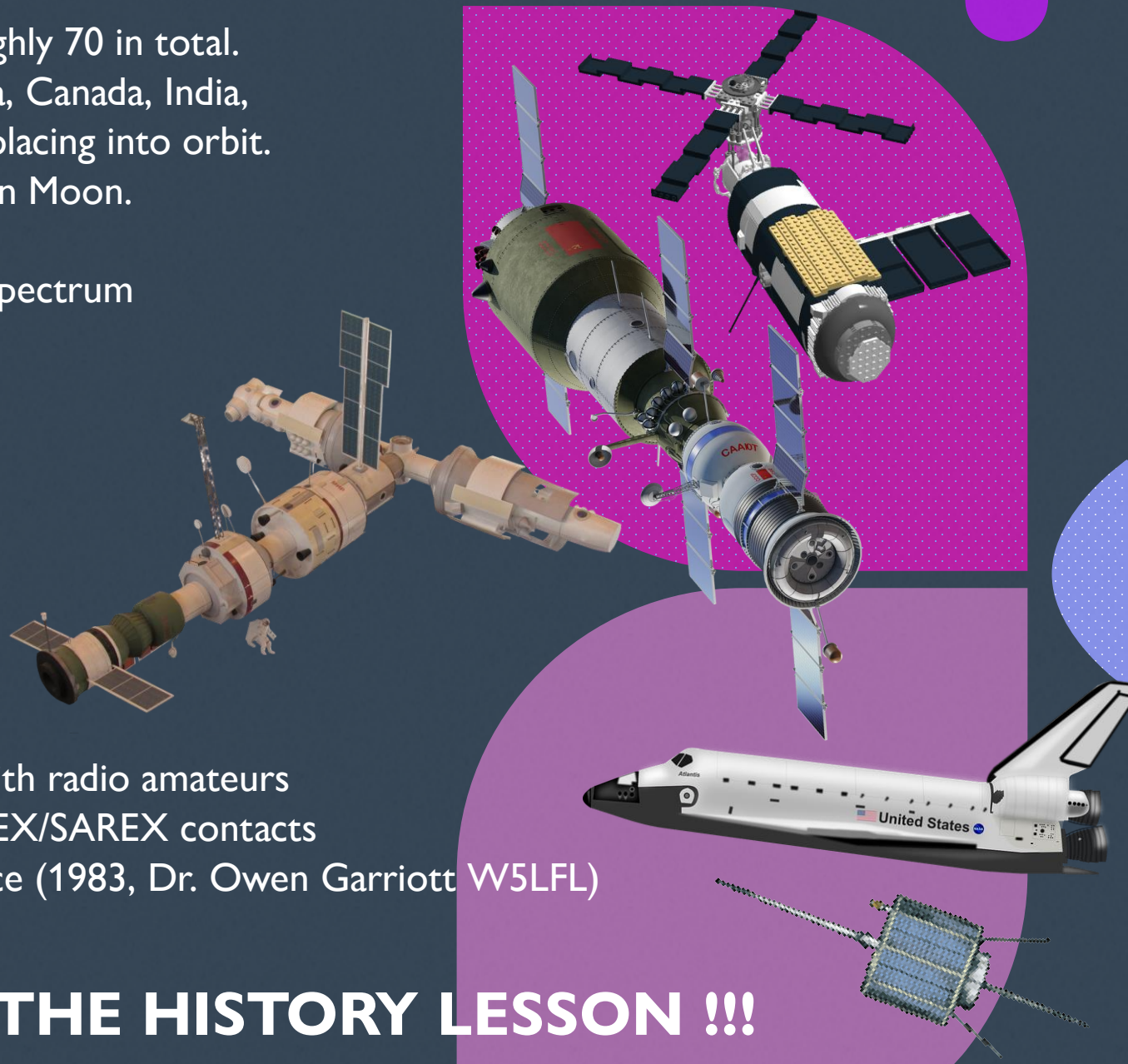
  - 70 humans into Earth orbit including 1st woman (1963, Tereshkova), 1st space walk (1965, Leonov), 1st computer (1965,Gemini 3), 1st live TV (1968, Apollo 7), and to orbit the Moon (1968, Apollo 8). And, then Moon landings!! (1969-1972)

  - 1st Successful Amateur Radio Satellite OSCAR 1 in order December 1961. More on this later.

Brief History of "Man Made" Radio Signals from "Space"

- **1970's Summary** – Space Station Competition
  - Higher success rate for satellites placed in orbit. Roughly 70 in total.
  - Japan, West Germany, USSR, France, UK, USA, China, Canada, India, Netherlands, Indonesia, Czechoslovakia as countries placing into orbit.
  - ~85 humans placed into orbit around Earth, and 12 on Moon.
  - Skylab and Salyut space stations!!
  - Increased use of communications satellite and radio spectrum
  - Interplanetary exploration to Venus and Mars
  - 6 amateur radio satellites between USA and Russia
  - 1st modern GPS satellite launched (Block 1, 1978)
  - OSCAR-7 (1974) still semi-functional in 2023.

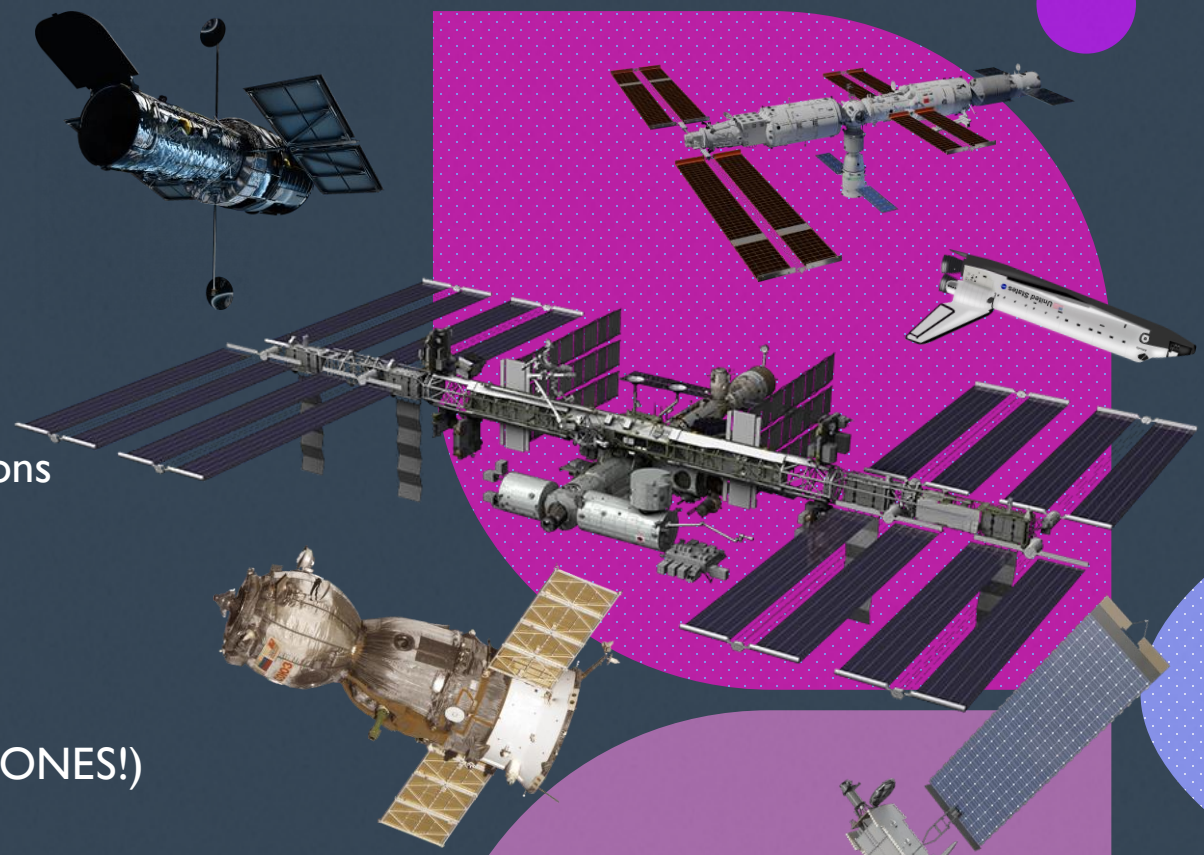
- **1980's Summary – Bigger in the 80's!**
  - More the 80 satellites placed into orbit
  - Many classified military satellites not accounted for?
  - Lots of "Free To Air" satellite options "unencrypted"
  - Mir Space Station cosmonauts make Earth contact with radio amateurs
  - US Space Shuttle Program goes mainstream and MIREX/SAREX contacts
  - 7 amateur radio satellites + first ham radio from space (1983, Dr. Owen Garriott W5LFL)
  - So much more…….



ALMOST ENOUGH WITH THE HISTORY LESSON !!!

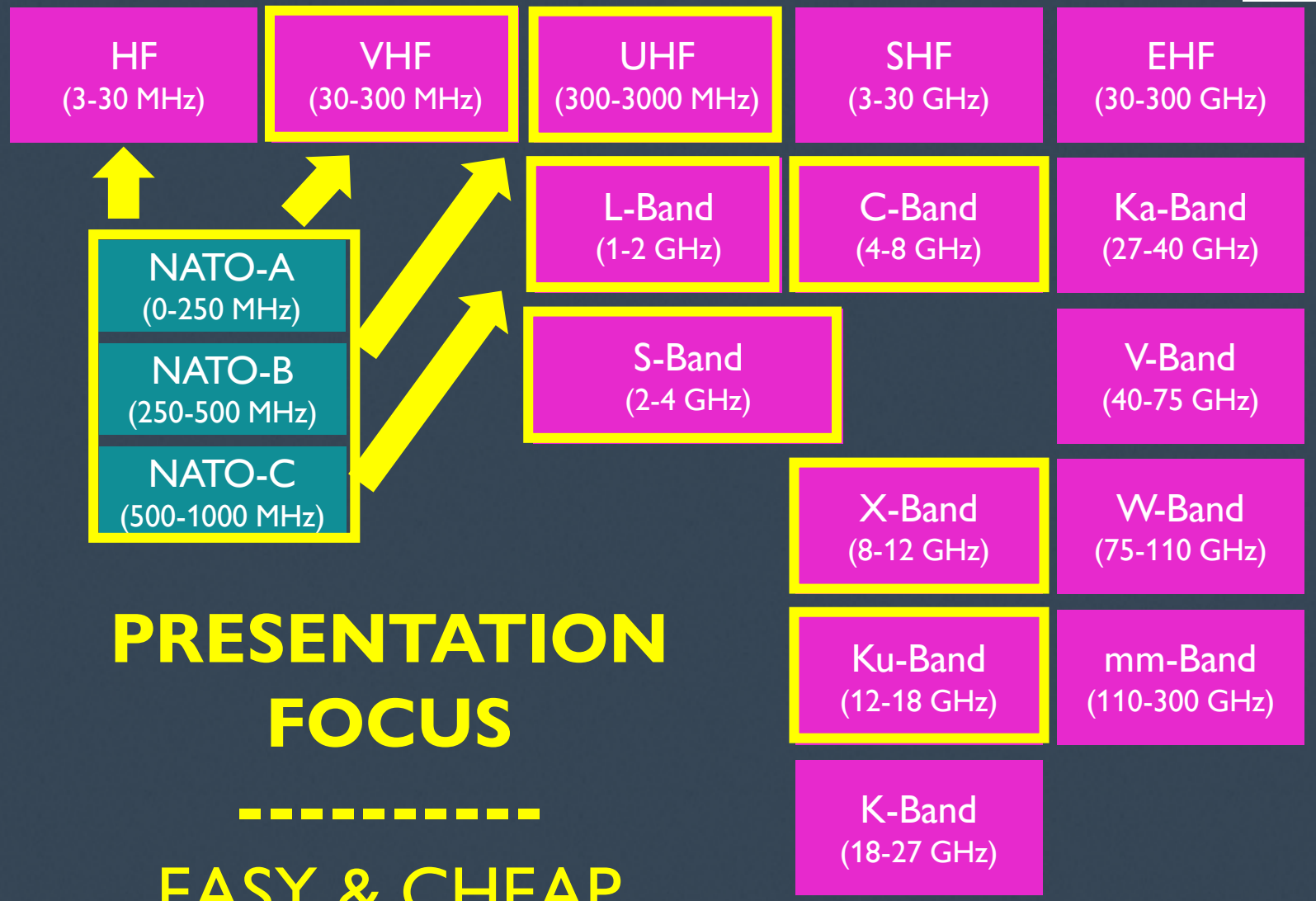
Modern "Man Made" Radio Signals from "Space"

- **1990's Summary – Building Something Big**
  - Most of the 1990's had a human in Earth orbit
  - Mir had international visitors
  - Hubble space telescope
  - International Space Station start construction 1998
  - The most AMSAT satellites launched so far.
  - More LEO satellites for educational use
  - More reliance on satellite for entertainment and communications
- **2000's Summary – Digital Decade**
  - Most of the 2000's had MORE THAN ONE human in orbit
  - Only for a short time in early 2000 was this not the case
  - Mir deorbited after 28 crews over 20 years
  - Free-To-Air entertainment starts to decline (C-Band, the BIG ONES!)
  - Rise of DTH/DVB "Small 20 Inch Satellite Dishes"
  - Last Space Shuttle flight (2011, 135 missions)
- **2010+ Summary – The time is now!!**
  - 104 satellites launched at once (2017, former record was 37 in 2014)
  - Educational LEO satellites very common (145 & 435-438 MHz)
  - China space station (2021,Tiangong) More experimentation not just analog signals



CUBESAT

Where to find signals from space today?



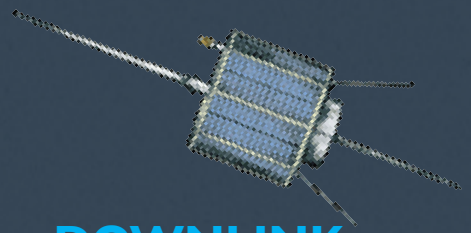
PRESENTATION FOCUS

EASY & CHEAP

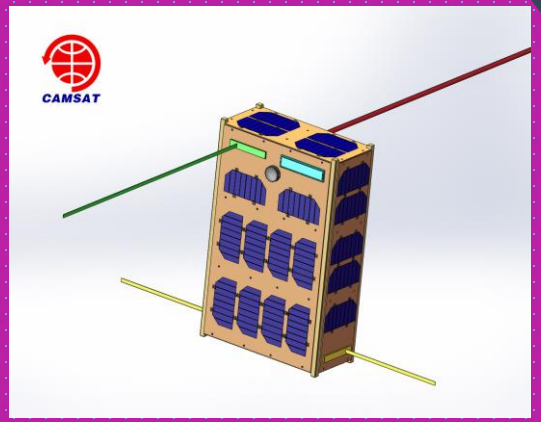
Where to find signals from space today?

HF
(3-30 MHz)

AO-7 (Launched 1974) | CAS-5A (FO-118, Fengtai-OSCAR 118, CAMSAT



Launched December 2022



DOWNLINK

29 MHz 10m HF Amateur Radio Band

UPLINK

Non-Operational 1981
Rebirth 2001

- DL 29.4-29.5 MHz SSB/CW
- DL 29.5020 MHz BEACON
- DL 145.975-145.925 SSB/CW
- DL 145.9775 MHz CW TLM
- DL 435.100 MHz CW TLM
- UL 145.850-145.950 SSB/CW
- UL 432.125-432.175 SSB/CW

DOWNLINK

UPLINK

- DL 435.570 MHz BEACON
- DL 435.650 MHz TELEMETRY 4800/9600bps
- DL 435.540 MHz (V/U 30kHz Linear Transponder)
- DL 435.600 MHz (V/U 16 kHz FM Transponder)
- DL 435.505 MHz (H/U 15 kHz Transponder)
- DL 145.975 MHz (Photo via FM, DTMF Control)
- UL 145.820 MHz (V/U 30 kHz Linear Transponder)
- UL 145.925 MHz (V/U 16 kHz FM Transponder)
- UL 21.435 MHz (H/U 15 kHz Transponder)

21 MHz 15m HF Amateur Radio Band

Where to find signals from space today?

VHF
(30-300 MHz)

VHF Weather Satellites

NOAA-15 (1998-2024)
- 137.62 MHz APT

NOAA-18 (2005-2024)
- 137.9125 MHz APT

NOAA-19 (2009-2024)
- 137.10 MHz APT

METEOR M2 (2014 – JAN 2023)
- 137.10 MHz LRPT

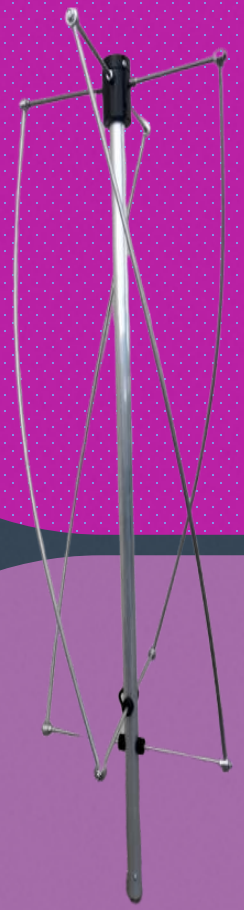
Amateur Satellites (VHF Downlink)

AO-91 (2017- Present)
- 145.960 MHz FM

PO-101 (2018- Present)
- 145.900 MHz FM

ISS (1998- Present)
- 145.800 MHz FM
- 145.825 MHz APRS

TIANHE-1 (2021- Present)
- 145.98723 MHz FM (NOT ACTIVE YET)
- 145.985 MHz FM (NOT ACTIVE YET)
- 145.825 MHz APRS (NOT ACTIVE YET)
- 145.985 MHz SSTV (NOT ACTIVE YET)

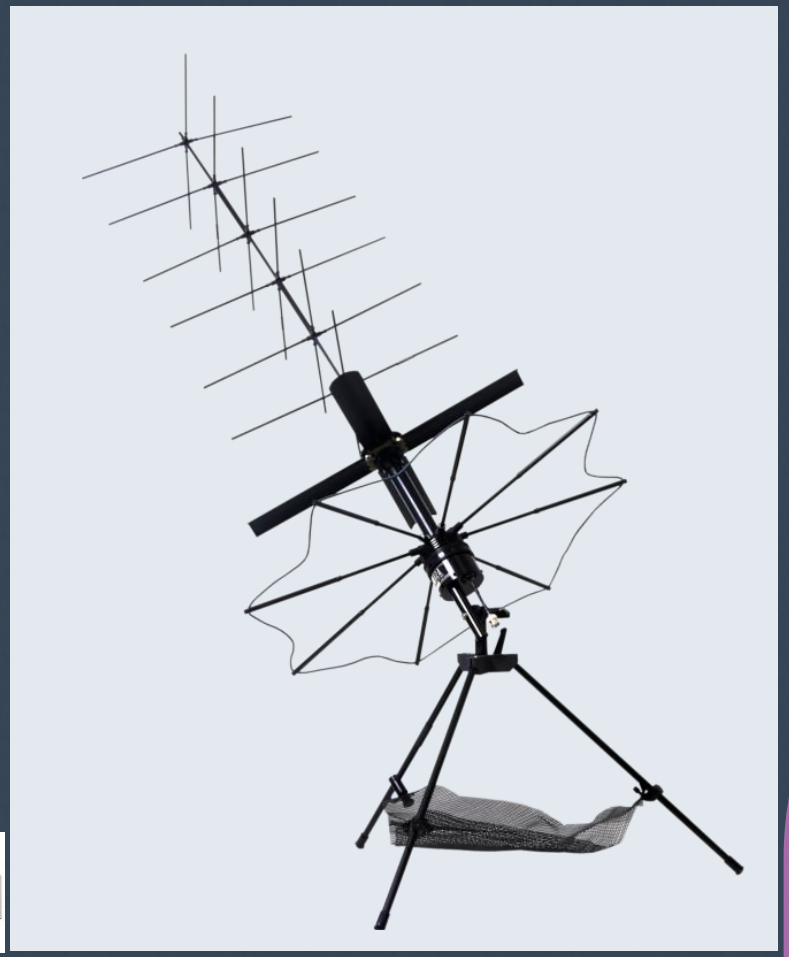


Where to find signals from space today?

VHF
(30-300 MHz)

UFO & FLTSATCOM

- Operated by US D.O.D
- Transponder satellites
- Directional antenna needed
- Listen between 240-270 MHz
- Easy to find. They do not move.
- Visit www.uhf-satcom.com for details



Radar & Ionospheric Modelling (NIMS)

- Long range radar & sensing
- 149/150, 180 MHz Pulse Transmissions

Where to find signals from space today?

UHF
(300-3000 MHz)

Not from space!

1.1090 MHz (ADS-B/1090ES)
2.1176.45 MHz (GPS L5 & GLONASS L5OCM & Baidou B2 NavIC L5)
3.1191.795 MHz (Baidou B2a/B2b)
4.1202.025 MHz (GLONASS L3OC)
5.1207.14 (GLONASS L3OCM & Baidou B2I/B2Q)
6.1227.60 (GPS L2)
7.1246 MHz (GLONASS L2)
8.1248.06 MHz (GLONASS L2OC & L2SC)
9.1268.52 MHz (Baidou B3I/B3Q/B3A)
10.1381.05 (GPS L3)
11.1544.5 MHz (COSPAT-SARSAT)
12.1561.098 MHz (Baidou B1Q)
13.1575.420 MHz (GPS L1 & GLONASS L1OCM & Baidou B1C/B1/B1A)
14.1600.995 MHz (GLONASS L1OC & L1SC)
15.1691.0 MHz (GOES-10 WEFAX & MeteoSat & GMS)
16.1685.7 MHz (GOES-10 GVAR PDUS & GOES-12 GVAR PDUS)
17.1694.1 MHz (GOES-16 HRIT/EMWIN & GOES-17 HRIT/EMWIN)
18.1698 MHz (NOAA-16 HRPT & NOAA-12 HRPT)
19.1702.5 MHz (NOAA-15 HRPT)
20.1707 MHz (NOAA-17 HRPT & NOAA-14 HRPT)

L BAND !!
1-2 GHz
“Lots To Do”

- -Weather
- -Navigation
- -Emergency messages
- -Other things..

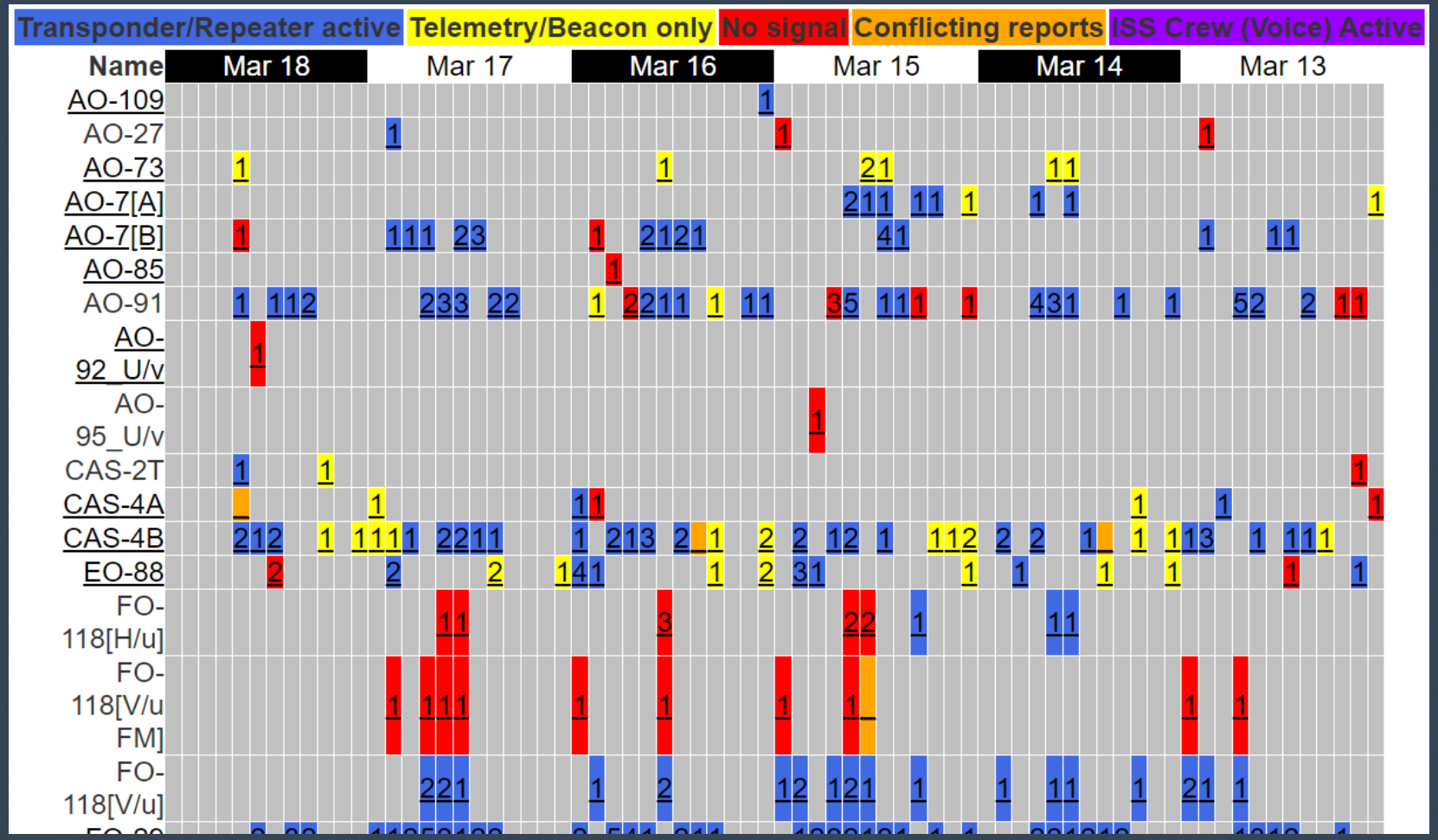
L-Band Patch Antenna
Get One!

Non-Man Made Also...

- 1420 MHz Hydrogen Line
- Radio Astronomy

Where to find signals from space today?

UHF
(300-3000 MHz)



www.amsat.org for full listing of UHF downlink and other details

ISM & 70cm Amateur Band

432 MHz & 435-438 MHz

Too many downlinks to list!

SPOTLIGHT

IO-117 Greencube

- MEO Elliptical Orbit (Rare)
- Launched by Italy 2022
- Botany experiments!
- 435.310 MHz
- Digipeater

Where to find signals from space today?

UHF
(300-3000 MHz)

- Signals are very data focused. Is that boring?
- Antenna are small. 88cm dish with 3.5 turn helical feed easy to build
- Likely you will need a pre-amplifier
- Signals make it easy to figure out where they are coming from
- Most transmissions are space to Earth
- Some effects from water but not an issue for space-to-space communications
- Great details on uhf-satcom.com website.
- You will need something better than the rtl-sdr V3
- ADALM Pluto, Lime SDR or HackRF is what you need

S BAND !!

"Space Band"

2-4 GHz

Where to find signals from space today?

SHF
(3-30 GHz)

C-Band Highlight: INMARSAT Active Series (1996-Present)

- Focused on maritime safety plus aviation support
- Global coverage through multiple satellites
- Able to monitor text, data and voice communications
- Inmarsat-2 F2 was in use from 1996 to 2014. Set a record.
- Easy to build antenna like used for S-Band
- Same equipment as Lime SDR, HackRF, ADALM Pluto
- Geostationary satellites easy to find.
- Guess what website is a good resource? www.uhf-satcom.com
- Also look at www.rtl-sdr.com blog

X-Band Highlight: Mostly weird military stuff.

- Most easy to find equipment won't work this high up
- This is for real deep divers

Ku Band Highlights: Some cool Free To Air + Starlink

- Easy to use cheap down converter known as an "LNB"
- Drops 12-18 GHz signals to 900-1200 MHz to use with cheap rtl-sdr V3
- Regular and easy to find satellite dishes work great.

C BAND !!
4-8 GHz
X BAND !!
8-12 GHz

Ku BAND !!
12-18 GHz

How to find these “space” signals?

Radio Hardware:

- Mostly covered already, but you need a receiver of some type
- The right antenna is VERY critical
- Higher the frequency the right antenna is EVEN MORE critical
- Feedline connecting receiver to antenna very important.

Computer Hardware

- Unless VHF/UHF audio transmissions, you need a computer for everything.
- More complicated signals need a good computer.
- Not some Win95/98 beige toaster oven! Level up please. 64 bit is your friend!
- Its good to record signals. I/Q recordings are fun. Benefit of SDR.

Software Recommendations

- SDRangel – For decoding and tracking
- SDR++ - For decoding, recording, etc
- HRPT Decoder – For those high-res weather images
- Inmarsat std-c decoder – For Inmarsat phone intercept
- Tracking – Too many to list. Orbitron, SatPC32, ones for your smartphone.

Is that all….. IS THAT ALL?????

HOW COULD I COVER

SUCH A HUGE TOPIC
IN A SHORT TIME

WHILE KEEPING YOUR ATTENTION

THANK YOU!!!

Questions??