EXTRA-TERRESTRIAL COMMUNICATION WITH HAM RADIO

SOME ASSEMBLY REQUIRED – BY GREG COLBURN – N3BYR

PRESENTATION BREAKDOWN

- Introduction – Greg N3BYR
- What is Extra-Terrestrial (E.T.) Communications and Examples
- Considerations with E.T. Communications
- Satellite Radio Communications for Ham Radio and example
- Moon Bounce Communications for Ham Radio and example
- Resources and more information
- Questions…

N3BYR – GREG COLBURN

- Mech and Elec Engineering Background (Comm and IT) – See Also Shady Tree Mechanic!
- Ham Operator since 1992 – First exposed to Satellite at Field Day 1995
- Primary Station is Weak Signal Focused VHF and above
- Satellite for over a year – EME for only a few months (Reading and Testing ideas still)
- I know nothing… Call me Jon Snow
- Some theories are still way above my head on paper.

WHAT IS E.T. COMMUNICATIONS

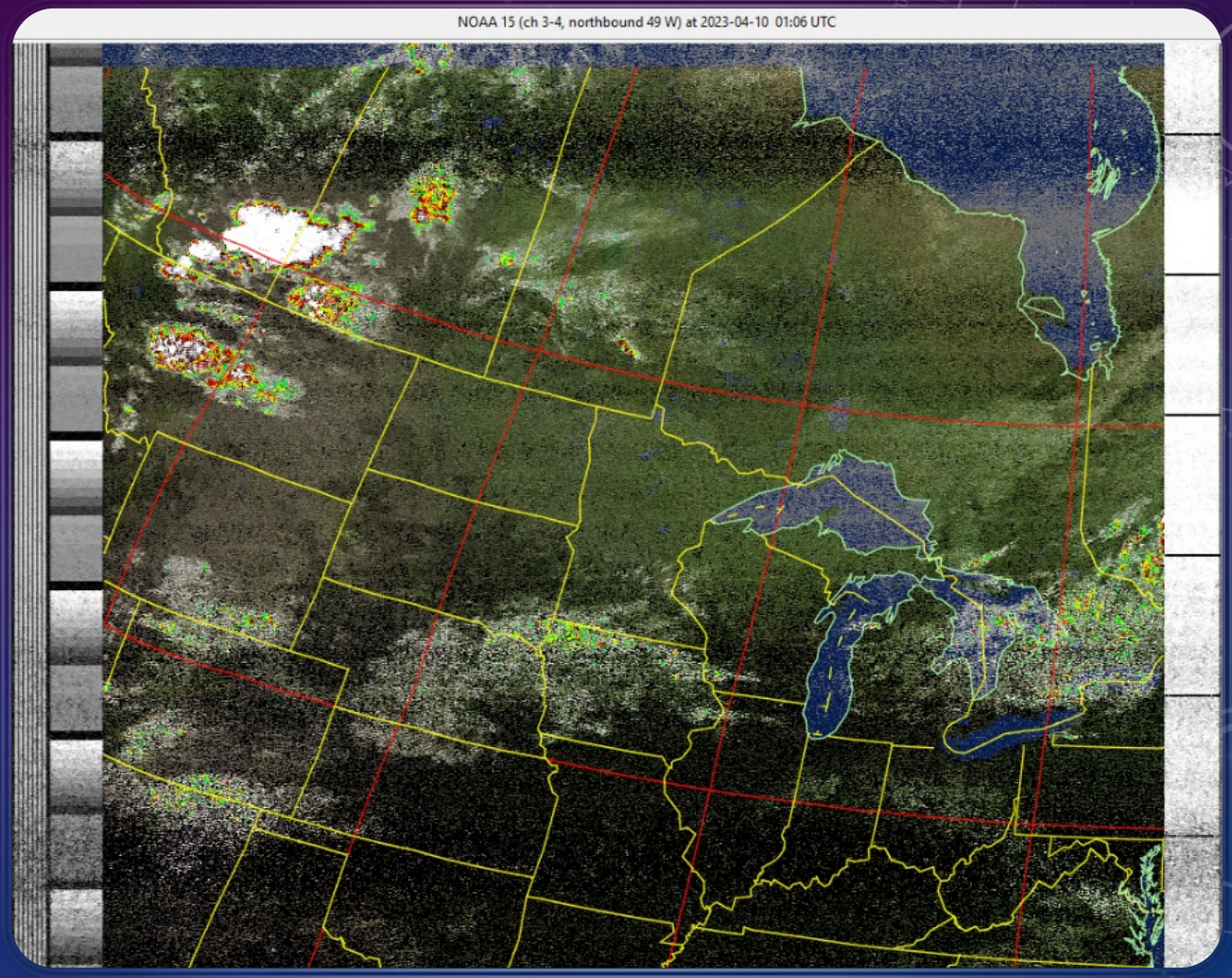
- Anytime we communicate beyond the Earth to non-terrestrial points (Stratosphere 10-31 miles, Mesosphere 31-53 miles, Thermosphere 53-375 miles, and Exosphere 375-6.2k miles up)
- Communication can be one-way or two-way
- Typically starts at frequencies above 30 MHz (VHF and up)due to the ionosphere layers reflectivity below 30Mhz*
- Extends into Microwaves and beyond (from UHF up to Visible Light!!)

*Signals below 30Mhz can enter the Ionosphere from space

EXAMPLES OF E.T. COMMUNICATIONS
WE USE IT A LOT MORE THAN YOU THINK! …THE LIST GOES ON…

- Satellite Communications (2-way up and down)
- WX Satellite Communications (1-way data and image transfer) <- HAM ACCESSIBLE TOO!
- Shuttle/ISS communications for NASA – Also includes lunar and Mars rovers
- Laser Moon Bounce – Reflectors installed on moon by Apollo Astronauts (Light waves)
- EME – Earth-Moon-Earth a.k.a. Moon Bounce (RF below light waves)
- GPS Satellites (1-way for position triangulation)
- Iridium (Text and Phone Calls)
- Satellite TV and Radio (Direct TV, Sirius Radio, etc.)
- Communication Links for Data Streams (Internet)

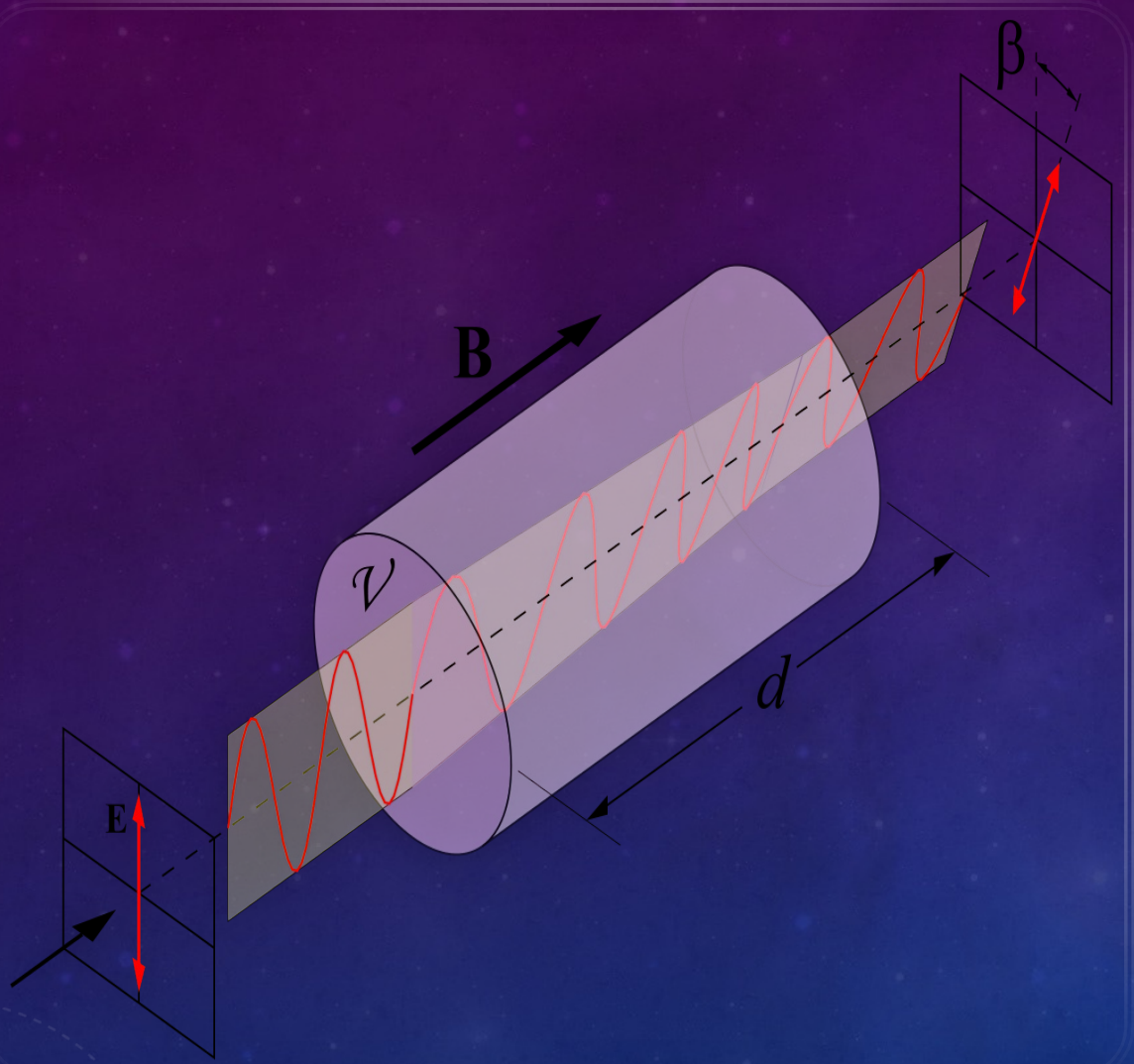
NOAA-15 APT IMAGE RECEIVED AT N3BYR



- Satellite Radio permits Hams to get weather satellite imagery!
- Very little equipment changes are needed
- Can be advantageous during major weather events.

CONSIDERATIONS

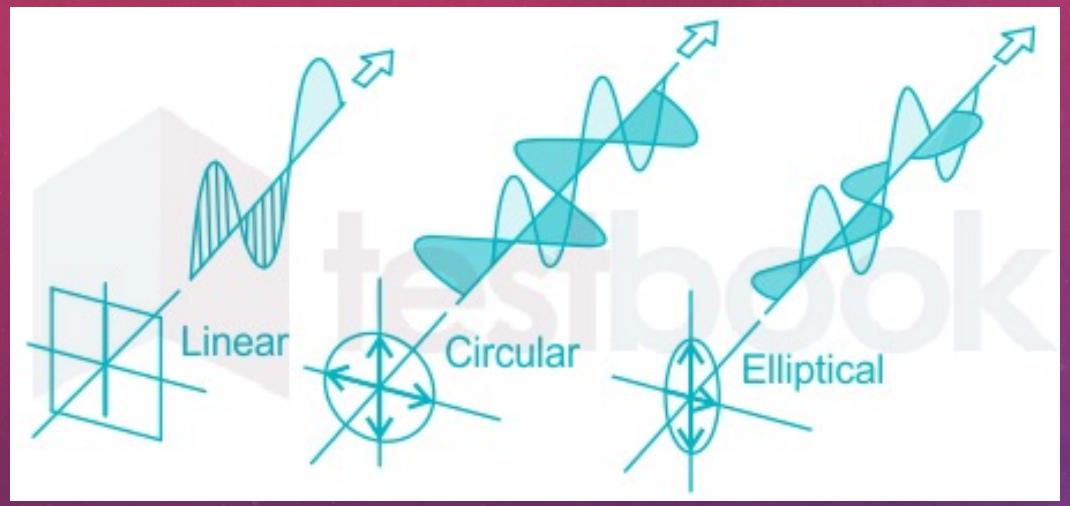
- Faraday Rotation (Polarization)
- Doppler Effect (Objects are moving?)
- Power Requirements (Distance)
- Antenna arrays (I need more than One?????)
- Method of Communications

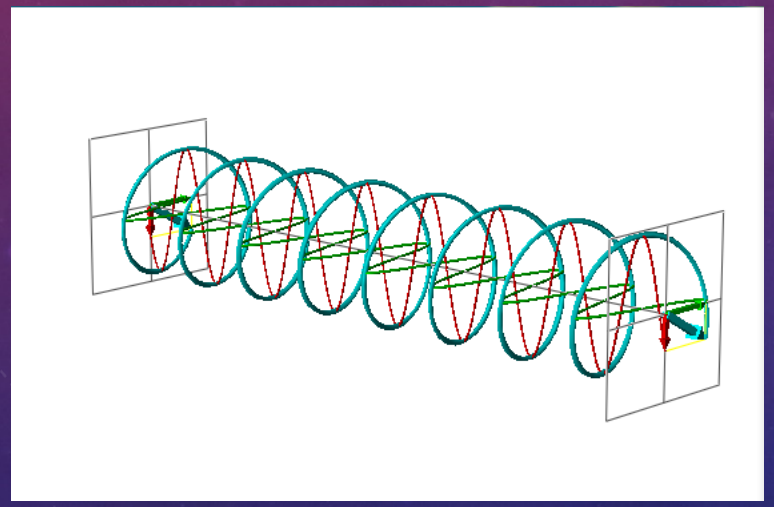


FARADAY ROTATION AND EFFECT ON RADIO SIGNALS

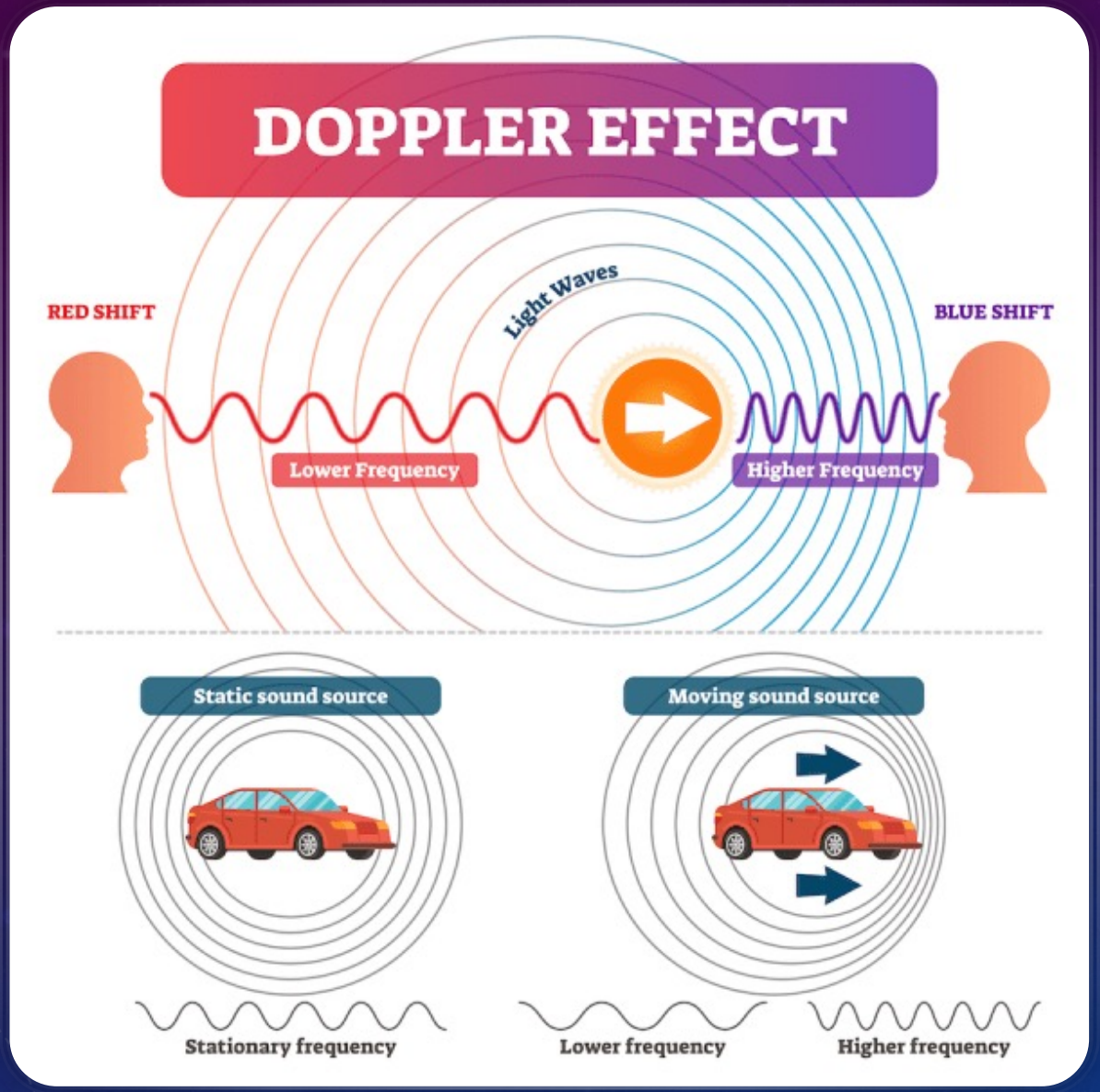
- The Faraday Effect can change polarization of signals as they pass through magnetic fields at various stages of the signal path including the ionosphere.
- This can change signal polarization from Horizontal to Vertical and makes linear polarization transmissions difficult
- Circular Polarization benefits from less effects of Faraday but still can be affected
- Elliptical Polarization can be affected by Faraday Rotation
- Faraday Rotation can be mild to extreme!

LINEAR, CIRCULAR, AND ELIPTICAL ANTENNAS





- Linear polarization is Vertical Polarization and Horizontal Polarization
- Circular Polarization can be RHCP (Right Hand) or LHCP (Left Hand) – Typical use in Amateur service is RHCP though LHCP is used
- Elliptical Polarization happens due to mismatch phasing or incorrect antenna offsets – This can be done on purpose and by accident!
- 20dB loss between Vert and Horz and 3dB loss between CP and Linear
- RHCP to LHCP causes signal rejection!!



THE DOPPLER EFFECT

- The Doppler Effect is present in all types of waveforms of energy
- In Radio communications this can cause subtle to dramatic shifts in frequency that we may not always notice.
- In cases where several kilocycles of Doppler is involved our radio reception needs to be compensated or we won't get the signal and miss the contact!
- The faster an object is moving, the more effect Doppler plays
- As an object passes you, its doppler will shift the other way dramatically!!

OTHER CONSIDERATIONS

- Power Requirements for some things are more important than others – Satellites are closer!
- Polarization at the receiving station may require the same, opposite, or a CP polarization
- Feedline losses really need to be considered – a negative 2dB signal loss is 20% loss - 3dB = 50%!
- Digital modes vary with success – Quick and Dirty VS Slow and Reliable
- Antenna Elevation and Azimuth are more critical with narrower beam widths!!!

AMATEUR RADIO SATELLITE COMMUNICATIONS

OSCAR (ORBITING SATELLITE CARRYING AMATEUR RADIO)

- Very first Man-made satellite was Sputnik 1 – Oct 4th 1957 launched by the USSR
- OSCAR is the official AMSAT (Amateur Satellite Organization) title for Ham Radio Satellites
- Most OSCAR are Low Earth Orbit (LEO) – Though we do have satellites further out in space for Ham Radio - Europe has at least 1 Geostationary (High Earth Orbit) Satellite
- First OSCAR satellite – OSCAR-I - was launched Dec 12th, 1961 – 52 years ago!!! On TX'd "HI" in CW
- OSCAR III launched Mar 9th, 1965, and first ever 2-way Ham Satellite – 16 days due to battery failure
- OSCAR VII – AO-7 launched Nov 1974 – Battery Charge Failure in 1981 – Re-emerged in 2002!!
- Many more launched since – Most Recent is GreenCube IO-117 which is a Medium Earth Orbit Sat

COMMON FACTS ABOUT HAM SATELLITES

- Most Satellite Operators refer to satellites as “Birds” and you will hear this VERY OFTEN in discussions
- Satellites are primarily on 2 meter and 70-centimeter bands – Some have used 10m
- Amateur Satellites avg. output power is ~250 milliwatts – AO-7 has a 2-watt transmitter on 10m!
- It takes roughly 80 watts ERIP to reach a satellite but is possible on an HT ducky at 5 watts!!
- Faraday Rotation can create a “Lock-Out” for stations using linear polarization occasionally
- Satellites have beacons – some transmit telemetry (Temp, Time, Status, Etc.)
- Satellites operate as linear transponders (SSB and CW), FM repeaters, or packet Digipeaters
- Some have multimode abilities (SSB and/or FM and/or Digipeater)
- Satellites are as small as a few inches square to a couple feet square with one or two omni antennas
- Satellites cruise at a mild speed of around 17.500 miles per hour - Not too fast, right?

LINEAR TRANSPONDER AND FM SATELLITES

- An FM Satellite functions the same way an FM Cross-band repeated. The Input Frequency is on one band and the output is on a second band. (e.g., You transmit on a 2m frequency compensated for doppler, and you receive on a 70cm frequency compensated for doppler)
- A Linear transponder does not have a specific frequency, instead it has a receive range and an output range. Normal mode and Reverse mode transponders effectively cover a “slice” of bandwidth on one band and retransmit the received signal on a “slice” of bandwidth on the second band.
    - A Normal Transponder takes the uplink (transmitted frequency) and spits it out around the same place on the downlink. E.G., if the frequency range uplink is 145.300 – 145.600 and downlink is 435.300 – 435.600 a signal transmitted to 145.350 would expect a downlink signal at 435.350
    - A Reverse Transponder takes the uplink signal and spits it out at the reverse side of the downlink “slice”. E.G., if the uplink is 145.300 – 145.600 and the downlink is 435.300 – 435.600 a signal transmitted at 145.350 would be transmitted back to Earth on 435.550. A transmitted signal at 145.550 would come back down at 435.350.

MOST COMMON MYTHS

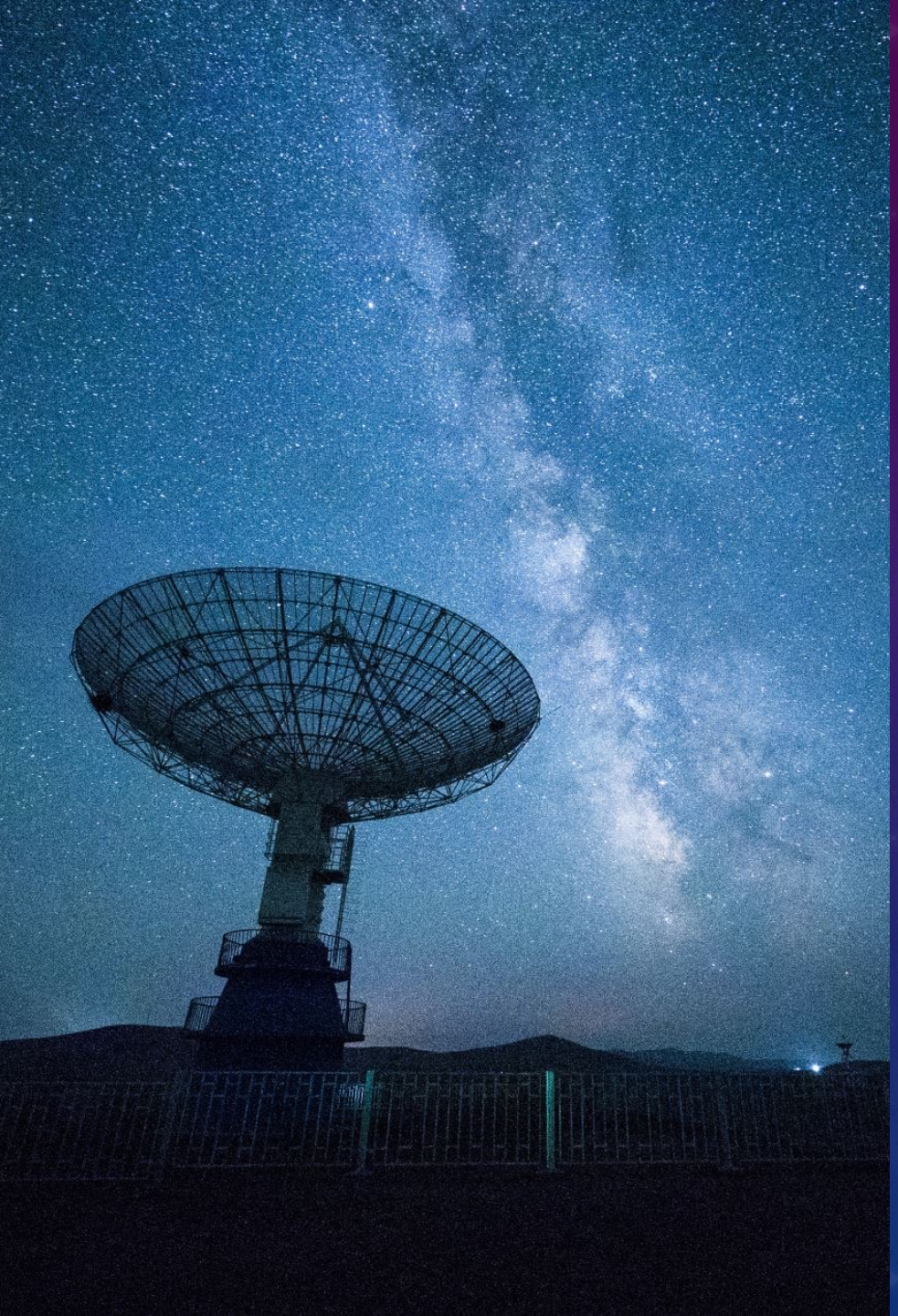
- Satellites take very special gear to work – FALSE – You can work them on almost any radio that has the correct frequencies, it helps to have a full-duplex transceiver (Listen on 2m and TX on 70cm or vice versa)
- You need a large antenna or Circular Polarized Antenna – FALSE – You can use a small Yagi or even an omni directional antenna that is radiating towards the the sky
- You need a lot of power – FALSE – 5 watts in an antenna with 5-9dBi can work many satellites
- You need a specialized tracking rotor to follow and work a satellite – FALSE (sort of) - You need to radiate the power in the general direction of the satellite – depending on the beam width of the antenna you have a lot of room for error
- You need a degree in mathematics to determine the Doppler and Position of a Satellite – FALSE – Many software programs determine this for you and can control the radio. There are also MANY FM charts for satellites on the web that help you set program channels in HTs to be able to work FM birds!!!

JUST HOW EASY CAN IT BE??

My first Sat contacts were made on Horizontal beams on my tower. I moved to a tripod with an azimuth rotor and a piece of conduit bent backwards 25 degrees – I had to manually follow the satellite which was easy

Antennas were quite literally on-the-cheap with a Diamond 10 element 430Mhz and Diamond 10 element 144Mhz antennas – You could potentially order something cheaper though too!

While my first satellite radio was a FT-736r – a dual-band mobile or HT could easily be used for FM satellites. There are several radios on the market second-hand that can do SSB Satellite mode or you can pair up two radios!



MAKING A CONTACT ON RS-44

Note: Satellites only have a split-second echo – Unlike EME

Video is on Youtube at https://youtu.be/LpX0F-MjQ7E

MOON BOUNCE

…TO INFINITY AND BEYOND

…TO BOLDLY GO WHERE

“THE ULTIMATE HAM RADIO DX”

LISTEN TO THE SOUND OF EME DIGITAL

WHAT IS MOON BOUNCE AND SOME FACTS

- The theory was proposed in 1940 by W.J. Bray of the British General Post Office to use the Moon as a passive reflector – Early theories exist as far back as 1928
- Germans were the first to document observed radar reflections from the Moon in 1943
- The first successful attempt at EME was conducted Jan 10, 1946 for Project Diana headed by John DeWitt – This was done with radar equipment and lead to radio astronomy techniques, not communications
- A Moon Relay project was started in the 1950's with the US Naval Reseach Labroratory – This idea grew from a military espionage program known as Passive Moon Relay PAMOR, which sought to eavesdrop on soviet military radar signals reflected at the moon. First Military voice communications occurred between California and Maryland on July 24, 1954

MOON BOUNCE AND HAM RADIO

- The first Ham Radio contact occurred July 17th, 1960 between California and Massachusetts on 1296MHz using 1000 watts of power and highly sensitive parametric preamplifier with Parabolic antennas
- The FCC has since allocated spectrum in the amateur radio bands starting in the VHF spectrum that are specifically reserved for Moon Bounce radio communications.
- Initial Moon bounce stations were CW and Phone communications – These later also included digital modes. Today the most prevalent two are JT65 and Q65.
- As computers have gotten more sophisticated, the ability to detect signals and decode them have improved dramatically. This allows stations with less “Horse Power” to make contacts via EME
- Moon bounce still takes an impressive amount of effort as the signal losses are very high!

HOW FAR AWAY IS THE MOON??

- The Moon is roughly 238,900 miles away from Earth (384,400 kilometers) – The Earth is 24,901 miles (40,070 kilometers) around at the equator – That means the Moon is ~9.5 times as far from Earth as the Earth is round.
- The Moon orbit changes with apogee and perigee. The apogee is when the Moon is farther away, the perigee is when it is closer. This distance varies throughout the year.
- It takes around 2.7 seconds for a radio signal to travel from Earth to the Moon and back again!

The below sound clip is Bernd DL7APV and curtesy of him for this presentation – First CW and then SSB moon bounce.

FACTS ABOUT MOON BOUNCE

- The Doppler effect is not as pronounced – The Moon creeps along at around only 2,288 MPH – Doppler offset is still required and most EME stations base their doppler off “Constant Frequency on Moon” (CFOM) as this simplifies both stations settings for Doppler
- Below 1296 most stations are running linear polarization and Faraday Rotation compensation needs to be available (Stations with CP have less issues) Both stations need to coordinate polarization changes
- More antennas and more power means a higher probability of making a contact – The loss for EME path on 432MHz is greater than 263dB and only ~7% of signal is reflected from the Moon! The Moon is also not a flat surface or mirror! Apogee and Perigee distance can account for more or less loss!!
- Planning is a huge part – You don’t just call CQ – Typically you coordinate by email or even through chat rooms to adjust and ensure the other station is QRV (Ready)
- My first EME contact took a whole hour to simply make the contact and exchange grids!
- Moon bounce is not impossible, but it is difficult. 2, 4, or 8 Yagi's with 500 watts of power makes contacts much easier than 1 Yagi and 20 watts – But it IS possible to do! Yes, there are “QRP” stations!
- Faraday Rotation can ruin your night – You can get locked-out of making contacts simply from Faraday Effect
- Sun noise is a thing! I am still learning about it – this is a signal source that can be used to test a stations sensitivity levels and performance BUT solar flares can also wipe out contacts!

THINGS TO CONSIDER WHEN ATTEMPTING EME

- Do research – It will help when you get frustrated or do not understand why something doesn't work
- Learn about the digital modes used like Q65-60B and learn WSJT-X first to understand how these types of communication work – It will make life much easier in general for the digital contacts.
- Understand or learn to calculate and estimate your ERP, ERIP, signal loss on Coax
- Join an EME group or follow a chat room and listen first a few times with your gear – see what you can and cannot hear and try to figure out why something is or is not working!
- Get a radio that has a high stability – This makes calculating doppler a lot easier and less chance that you will miss the contact. A slight drift in the shack is a major drift for the receiving station on transmissions
- EME is possible – and it does take effort, but not astronomical amounts of effort – Try the "Big Guns" stations first that are willing to both take the time and to mentor in the process
- Frequency Stability is critical for EME, especially digital! Most stations are using stable QRP rigs (Elecraft or similar) and using a linear amplifier to handle the power to keep the heat out of the radio. Some utilize frequency reference devices.
- Most of all… take your time and expect a few failures – they happen to everyone, including the "Mega EME Stations" – it takes time.

MY FIRST EME CONTACT – WAS IT HARD?

- I showed interest on a few pages and chat groups, and a German Ham reached out to me (DL7APV) and wanted to help me make that first contact – His station is HUGE
- It took about 45 minutes to get everything right – I had a few settings incorrect and as soon as I adjusted those, I was able to ”hear” the other EME stations
- I only used a single 8+8 element RHCP antenna that has 13.3dBi gain with 80 watts out to the antenna (ERIP with coax losses were ~1000 watts)
- Coax was less than ideal with LMR400 to the tripod and LMR400UF from the point of rotation to the antenna. LMR600 would be more ideal with less loss at 432MHz
- My antenna was only 6’ off the ground – For EME towers are not needed, just a view of the sky!
- Working the larger stations is quite possible – But to work medium or small stations you will need a lot more antenna

HOW BIG IS A “BIG GUN EME STATION”?

- Stations vary from 1 parabolic dish (HIGH gain) to a large array of Yagi
- Power output is typically from 200 to 1KW – the ERIP becomes a huge number at this point
- Some guys just have all the fun!

RESOURCES – VISIT MY PAGE FOR LINKS

I try to keep information and links on my website that are relevant and up – I have links on the page for EME and Satellite information for everyone to check out. Also, I recommend googling what you can and continue to learn and grow as a Ham Radio Operator!!

https://www.n3byr.com

Special Thanks to Bernd DL7APV – Both for your patience with me and mentoring on EME!!

QUESTIONS???

I can be reached by email also at

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