Wireless Satellite Communication

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Introduction

The sky is full of manmade communication satellites. The race to put these into the air started in with the launch of Sputnik 1 on October 4, 1957. Sputnik 1 is also the first item that labeled with a NORAD ID. Within years, the sky was full of various satellites. The cost per pound of launching payloads has been quickly declining. It was something that only governments with large budgets could first afford to do.Satellites come in many shapes and sizes. But most have at least two parts in common - an antenna and a power source. The antenna is used to send and receive information. The power source can be a solar panel or battery. Solar panels make power by turning sunlight into electricity. The cost in 2011 the cost was about $3,000 per pound (Kestenbaum, 2011). Falcon Heavy is estimated to be about $1,000 per pound. This explosion of satellites allowed for new cheap wireless communication without direct line of sight of both parties. The world would look completely differently than it does now as the space race was started with satellites.

Amateur Radio Satellites

Many people are astonished to discover that Amateur Radio satellites are not new. In fact, the story of Amateur Radio satellites is as old as the Space Age itself. The Space Age is said to have begun on October 4, 1957. That was the day when the Soviet Union shocked the world by launching Sputnik 1, the first artificial satellite. Hams throughout the world monitored Sputnik’s telemetry beacons at 20.005 and 40.002 MHz as it orbited the Earth. During Sputnik’s 22-day voyage, Amateur Radio was in the media spotlight since hams were among the few civilian sources of news about the revolutionary spacecraft. Almost four months later, the United States responded with the launch of the Explorer 1 satellite on

January 31, 1958. At about that same time, a group of Amateur Radio operators on the West Coast began considering the possibility of a ham satellite. This group later organized itself as Project OSCAR (OSCAR is an acronym meaning Orbiting Satellite Carrying Amateur Radio) with the expressed aim of building and launching amateur satellites. After a series of high-level exchanges with the American Radio Relay League and the United States Air Force, Project OSCAR secured a launch opportunity. The first Amateur Radio satellite, known as OSCAR 1, would "piggyback" with the Discoverer 36 spacecraft being launched from Vandenberg Air Force Base in California. Both "birds"successfully reached low Earth orbit on the morning of December 12, 1961. OSCAR 1 weighed only 10 pounds. It was built, quite literally, in the basements and garages of the Project OSCAR team. It carried a small beacon transmitter that allowed ground stations to measure radio propagation through the ionosphere. The beacon also transmitted telemetry indicating the internal temperature of the satellite. OSCAR 1 was an overwhelming success. More than 570 amateurs in 28 countries forwarded observations to the Project OSCAR data collection center. OSCAR 1 lasted only 22 days in orbit before burning up as it reentered the atmosphere, but Amateur Radio's "low tech" entry into the high tech world of space travel had been firmly secured. When scientific groups asked the Air Force for advice on secondary payloads, the Air Force suggested they study the OSCAR design. What's more, OSCAR 1's bargain-basement procurement approach and management philosophy would become the hallmark of all the OSCAR satellite projects that followed, even to this day. Since then, amateurs have successfully built and launched dozens of satellites, each one progressively more sophisticated than the last.

Due to the high orbital speed of the amateur-satellites, the uplink and downlink frequencies will vary during the course of a satellite pass. This phenomenon is known as the Doppler effect. While the satellite is moving towards the ground station, the downlink frequency will appear to be higher than normal and therefore, the receiver frequency at the ground station must be adjusted higher in order to continue receiving the satellite. The satellite in turn, will be receiving the uplink signal at a higher frequency than normal so the ground station's transmitted uplink frequency must be lower in order to be received by the satellite. After the satellite passes overhead and begins to move away, this process reverses itself. The downlink frequency will appear lower and the uplink frequency will need to be adjusted higher. The following mathematical formulas relate the doppler shift to the velocity of the satellite:

Change in frequency	Downlink Correction	Uplink Correction
$\Delta f = f \times \frac{v}{c}$	$f_d = f(1 + \frac{v}{c})$	$f_u = f(1 - \frac{v}{c})$

In this project we are looking at OSCARs. OSCAR is Orbiting Satellite Carrying Amateur Radio. 2. 19 different satellites have been launched. OSCARs are fast moving satellites with OSCAR 11 having only about 10 min window overhead for example.

UO-11 carries beacons in three amateur radio bands:

1. The 145.826 MHz beacon transmits FM Audio Frequency Shift Keying (AFSK) 1200 bps ASCII data. It the early years it also transmitted a voice message from the digitalker experiment.
2. The 435.025 MHz beacon transmitted either 1200 bps FM AFSK or 4800 bps PSK data. This beacon was used to downlink information from the Digital Store and Readout (DSR) Experiment, which includes CCD Earth image data, results from the Particle Wave Experiment, and engineering data from the RCA COSMAC 1802 CPU.

3. The 2401.5 MHz beacon transmitted FM and PSK signals. Antenna polarization for all three beacon transmitters is left-hand circular (LHCP). Only the 145.826 MHz beacon is now operational.

Many of the OSCAR satellite use UHF and VHF using FM or SSB. The radio used in this project is an FM radio. Anything we hear might can't be used for commercial uses or disclosed.

Laws and Applicable Rules

The first thing to be aware of is neither of us have an operator's license for ham radio. 47 C.F.R, Part 97. The law is clear about a few things included that no small base station can transmit with more than 5W of power (47 CFR 95.135). Transmitting will be prohibited for us. We will have to limit our work to passive listening. (Quora, n.d.).

Required hardware for attempting to listen to a satellite

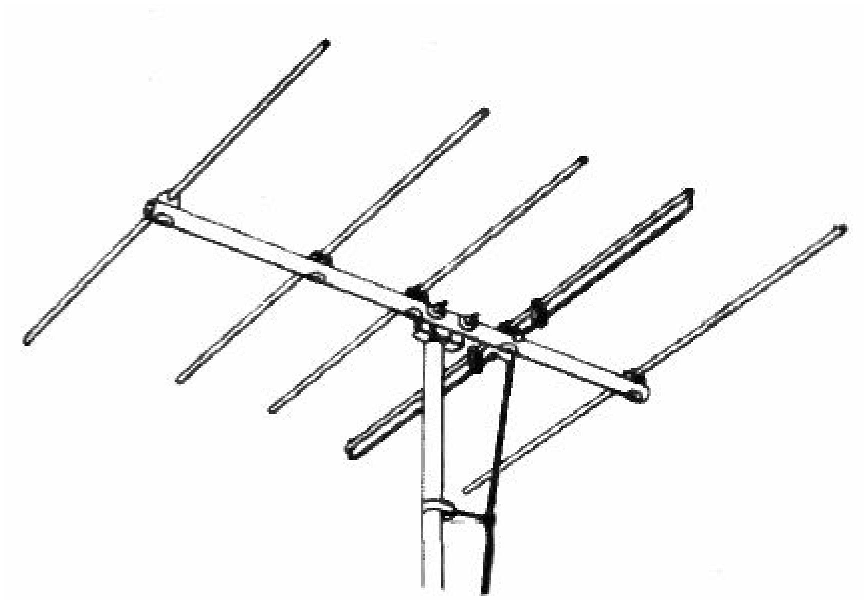
The budget was under a $100. Most of it which was used on a radio and the wire needed to make the antenna. Yagi Antenna is a lightweight cheap high gain antenna that could receive from a satellite.

Requirements for building an antenna for reaching a satellite

Many Satellites use 2 meter and 71 cm wavelengths. The antenna would need to be able to pick up these two bands. Making the antenna a half wavelength also makes the antenna smaller and easer to hold and transported. It must have 1 meter elements for 2 meter wavelength to pick up signals near 150 MHz, and another set of elements 35.5 cm for 71 cm wavelength near 420 Mhz.

How Yagi Antennas Works

Yagi antenna, is a directional antenna consisting of multiple parallel elements in a line, usually half-wave dipoles made of metal rods.



Yagi antennas create forward gain, meaning it gives up gain in one or more directions to get more in a given direction. All Yagi has 3 major elements, Reflector, Detector, and at least one Director. The Reflector and Director are called “Parasitic” and are named such because it doesn't electrically connected to the radio. (htt) Directors resonate when excited by the waves like a simple dipole antenna, and the repeating Directors create a constructive interference increasing directional gain.

The bandwidth of the antenna is the frequency range between the frequencies at which the gain drops 3 dB (one-half the power) below its maximum. The Yagi–Uda array in its basic form has very narrow bandwidth, 2–3 percent of the centre frequency.There is a tradeoff between gain and bandwidth, with the bandwidth narrowing as more elements are used.

How to Find Satellites in Sky

Starting with Azimuth covers the east or west direction to point the antenna. It's based on your location. (compussdude, n.d.) This information is standardized into a Two Line Element Set. It gives all the information needed to locate a satellite in the sky. The second part of information is the Inclination. The inclination is the angle from the horizon after braking the visible edge of earth. The information is accessible and automated with two sites, N2yo.com provides all the information on tracked satellites in real time. Heavens-above.com and its smart phone app gives updates and notifications of what satellites are overhead now and in the next hour.

Outcome

Attempted to listen to the downlink of Oscar 11. The frequency of 145.825 using FM. wasn't have to audibility signal.

Didn’t point the antenna in the correct location in the sky

A really simple reason for not picking up a single might be that the antennae is not pointed correctly. Most problems with satellite communication is a aiming issue.

Antenna might be out of tune/not built correctly

Further testing of the antenna is required to rule out the antenna

Signals where picked up, however indicatable from static

Terms Associated with Satellites

1. Very high frequency (VHF) ~2 meter wavelength
2. Ultra High Frequency (UHF) ~70 cm wavelength
3. Downlink: the frequency is the frequency the satellite relays the uplink transmissions upon.
4. Uplink: is the frequency which satellite listens to for transmission
5. Beacon: A signal normally at a given frequency that is used to broadcast the identity of the satellite.
6. NORAD ID/Satellite Catalog Number is a list of tracking terrestrial satellites.
7. Formerly, maintained by NORAD
8. International code used to track terrestrial satellites.
9. Perigee: The point where the satellite is closest to the earth.

10. Apogee: The point where the satellite is farthest from the earth.
11. Inclination: The angle between the plane of the orbit of a satellite and the Equatorial plane. An orbit of a perfectly-geostationary satellite has an inclination of 0 degrees.
12. Period: The amount of time it takes for it to circle the earth.
13. Semi major axis: Average distance the satellite is from the earth
14. Mode is the way the satellite transmits or accepts transmissions.
    a. D(RTTY) Radio Teletype
    b. CW Continuous Wave
    c. Audio Frequency Shift Keying (AFSK)
    d. Single Side Band Continuous Wave (SSB CW)
    e. Phase Shift Keying @ 31 bps (PSK31)
15. Tone Codes are prompts methods that “wake up” listing radios and repeaters
    a. Digital Tone Control: radios listen for a given digital inaudible tone.
    b. Tone Squelch (TSQL): given token is required to disable the squelch circuit; without it, squelch circuit doesn’t allow for the audio to be created from the radio frequency.
    c. Tone Codes help to conserve energy by not having the transmitter turn on unless it’s needed.

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