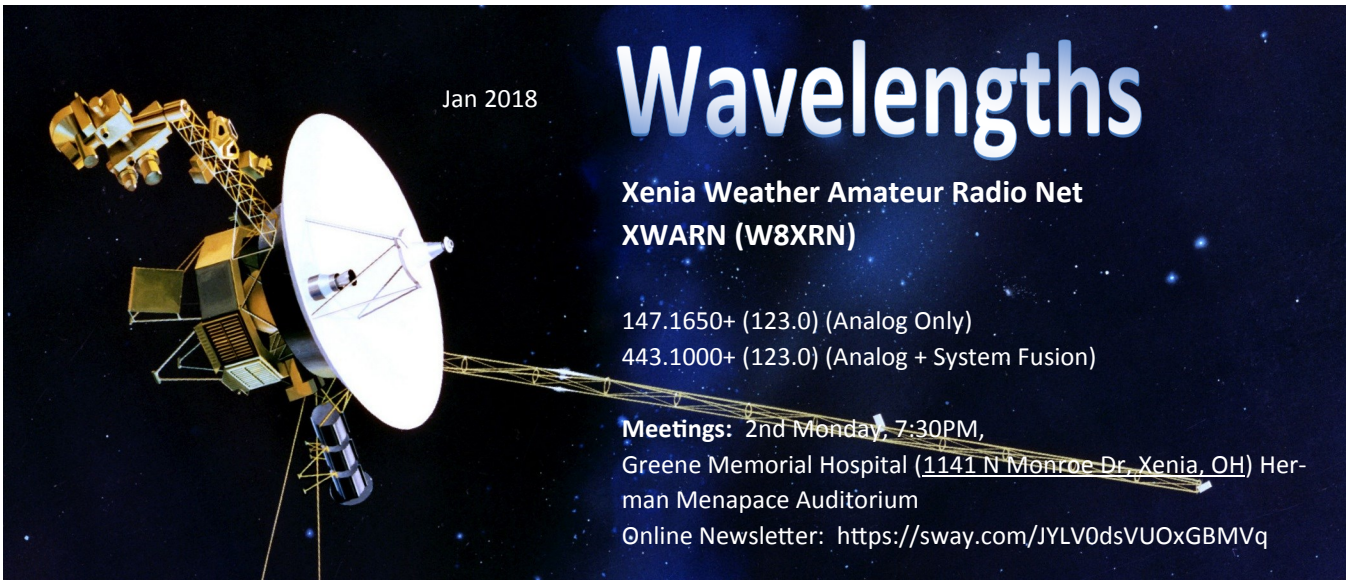

Artist's Conception of the Voyager Spacecraft

President's Message

In 2017 the club changed in a way that was both big and small. We are now incorporated with the State of Ohio. We intend to pursue recognition by the IRS as a not-for-profit tax-exempt organization. As a part of this process, we have made a few changes to the organizational documents that specifies how we do things. The small part is that we did not make any changes that are designed to change the character of the club or its primary mission of supporting the Greene County Weather Net.

Jason Bowman WG8B led the effort toward the incorporation. At the holiday party, I was pleased to present Jason with a certificate commemorating his induction into the XWARN Hall of Honor.

There was another noteworthy event for the club in 2017. Hamvention moved to our own neighborhood and took place at the Greene County Fairgrounds. Many of us were involved as volunteers. As in previous years, XWARN sold Hamvention t-shirts. This year, we sold out early Saturday morning. Steve Mackey N8ILR deserves special recognition for leading the shirt sale. Thanks, Steve!

(Continued on page 2)

Voyager Spacecraft Communications

In November, PBS broadcast a program called the "The Farthest" (https://goo.gl/pxvggf) about the Voyager Space Program. (also available on Netflix). It was probably one of the most astonishing and captivating 90 minutes of television that I have experienced in quite some time.

Particularly interesting in my opinion was what it took for the Voyager spacecraft to communicate over the vast distances within our solar system and then again on the Voyagers' interstellar mission. Speaking of which, did you know that Voyager 1 left our solar system and entered interstellar space on August 25, 2012? It was the first man-made object to do so.

The Voyager program began with the recognition that a rare planetary alignment, one that occurs only once every 176 years, was approaching. If they launched at the right time, it was possible to pass by Jupiter, Saturn, Uranus, and Neptune.

(Continued on page 3)

Club Contacts

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- Vice President, Brett Boggs, NV8I Vicepresident@xwarn.net
- Secretary, Jason Bowman secretary@xwarn.net
- Treasurer, Steve Mackey, N8ILR Treasurer@xwarn.net
- Repeater Guru, Jim Simpson, WB8QZZ Technical@xwarn.net
- Web Master John Seitz, N8ACU webpresence@xwarn.net
- Membership, Phil Verret, KA8ZKR membership@xwarn.net
- XWARN Trailer / Public Service, Mike Crawford, KC8GLE trailer@xwarn.net or publicservice@xwarn.net
- Newsletter, Jason Bowman, WG8B newsletter@xwarn.net

Calendar of Events

- Dec 31 Sat 1900-2100 (7-9PM). Resolution Run. Beavercreek HS, Dayton-Xenia at Fudge. 5k, VE test session, potluck snacks before. We provide comms and light the course with our headlights—we are never short of volunteers for this one, but don't miss out! [N8ADO]
- April 8. Sunday. All Day. Ohio River Road Runners Club Marathon. Xenia to Cedarville and back. Large event. Need many operators especially bike mobile. [N8ADO]
- May 18-20. Hamvention.

President's Message

(Continued from page 1)

As we enter the new year, we look forward to the coming upgrade of the 147.165 repeater. I am told that this should be "Real Soon, Now". Receiver sensitivity should be a little better, output power should be notably higher and the new controller will have some new capabilities.

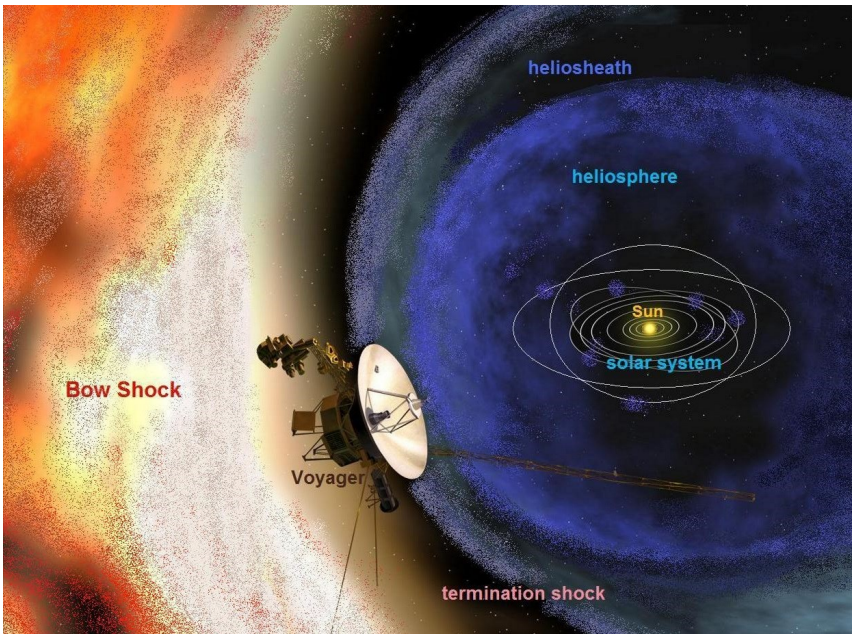
The National Weather Service has not set their training schedule for 2018, yet, but watch this space for news about spotter training sessions in the area.

See you at the next meeting on January 8! The "Dave Kalter Youth DXpedition" is planning a presentation for us.

Minutes Dec 2017—Holiday Party

This is the one meeting of the year where no club official business is conducted and instead we focus on celebrating the year. I don't have an official count, but between club members and family, we took up about 3/4 of the tables in the private room at Golden Corral. We played a game where we had to name the Christmas tune based on a pictorial representation of the song. Some of those were very tough. I think the number of Hershey Kisses in the jar was something like 135. Whatever number it was, I was only 15 off. But someone else was even closer. Awesome estimation skills to whoever that was! January 8, 2018 will be our next regular meeting. See you then!

Voyager Spacecraft Communications



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The Voyager spacecraft carry a variety of scientific instruments and a communications system powered by a Radioisotope Thermoelectric Generator or RTG. Voyagers' RTGs started with about 470W. But every year they lose about 4W due to radioactive decay. Voyager engineers predict that the power levels will have decayed to an unusable level for radio communications by the year 2025.

Once the critical point is reached, the Voyager command system will default to a backup mission after about 2 weeks of onboard troubleshooting and attempts to reestablish contact with Earth. Even though we won't be able to hear it, scientific and status information will continue to be transmitted until there isn't enough power to even run the basic heartbeat functions of the spacecraft. At that point, Voyagers' mission will be to carry the famous Golden Record (https://goo.gl/e854nd) to "infinity and beyond".

So how do we communicate with the Voyagers? Each Voyager has two (2) antennas, one high gain parabolic dish 3.6m in diameter that can receive and transmit over S (2.1GHz, 36dBi) and X (8.4 GHz, 48dBi) bands and one low gain S band (7dBi) antenna, which was only used to establish initial communications after launch.

(Continued on page 6)

XWARN Mission

The mission of the Xenia Weather Amateur Radio Net (XWARN) amateur radio club is to conduct weather spotting nets during severe weather and other communication services for the City Of Xenia and all other Greene County communities.

In this capacity, we are set up to provide communication services as required to the Greene County Ohio Public Service Agencies and other local government entities. The communications services provided to the supported agencies may be for emergency purposes or to simply enhance their communications abilities. On an as needed basis XWARN provides similar services to various government entities of our surrounding counties.

Additionally, XWARN provides communications support to various community organizations in support of marathons, 5K runs, 10K runs, bicycle events, etc. to provide health and safety assistance to the participants and sponsors of said events.

In support of these goals, XWARN operates and maintains amateur radio repeaters and other equipment in Greene County.

Ray Hollifield: Akron's Radio Sleuth

Times-Press Photo.
Ray Hollifield at work finding radio interference.

Excerpts from ohiohistory.org (https://goo.gl/bVKWob)

Most of us know the frustration of a broken television signal or disconnecting Wi-Fi. When this happens, we typically call our service providers and they might send someone to our homes to investigate the problem. As it turns out, during the 1930s, radio-owning Ohioans did much the same thing we do now - they contacted their service provider and someone was sent to investigate.

In Akron, Ohio, that investigator was a man named Ray Hollifield. Hollifield worked for the Ohio Edison Company during the 1930s and he was considered one of the masters of his craft. When a complaint came in, Hollifield would arrive in his truck, equipped with all of the materials he needed to do his work. Often the issue was an error with the customer's equipment, so Hollifield might recommend a reputable radio shop. However, if there was an error in the Ohio Edison equipment, Hollifield could act. Hollifield would drive around the block in this truck, using his noise meter to pinpoint the exact location of the problem. After finding the pole that was creating static, he would begin by hitting it with his 12 pound hammer. Hollifield could test his success using the radio in his car. If the static continued, he would climb the pole and make the necessary fixes.

Hollfield once appeared on a radio program in which he detailed how everyday families could identify and fight radio interference. In this interview, Hollifield pointed out that the culprits in many interference cases were electric appliances found in American homes during the 1930s. For example, an electric hand iron could cause a "frying hiss if the heating element is defective, and a coarse snapping and crackling sound if the cord plug or contact pins of the iron is burned or loose." Hollifield could listen to a faulty radio signal and know exactly what was causing the problem.

Christmas Caroling from the Antarctic

From ARRL.org (https://goo.gl/KHXXuY)

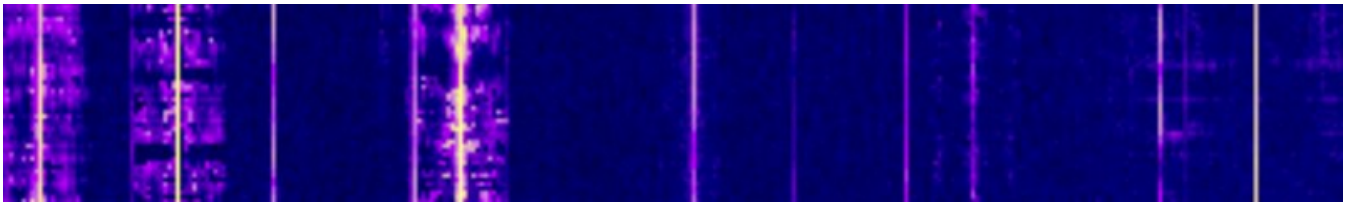
Each year, the "residents" of McMurdo Station, Antarctica, celebrate Christmas by singing and sharing Christmas Carols via HF (7995 kHz USB) for those at remote Antarctic field camps. They'll be doing it again in 2017, on Saturday, December 23, at 2300 UTC.

"Multiple stations are involved, each with different equipment," explained Nathaniel Frissell, W2NAF. "McMurdo Station and South Pole Station probably have the most powerful equipment. Field camps and remote stations could be calling in with systems that put out as little as 20 W."

"This year, we are asking ham radio operators around the world to listen in and e-mail shortwave listening reports telling us how far away the carols are heard," Frissell said. "Last time I did this, almost all of the positive QSL reports were from South Pole Station."

A YouTube recording offers a sample (https://goo.gl/ghj3ER) of last year's transmission.

Automated Mode Identification



From Hackaday (https://goo.gl/C7TzEK)

Identifying ham radio signals used to be easy. Beeps were Morse code, voice was AM unless it sounded like Donald Duck in which case it was sideband. But there are dozens of modes in common use now including TV, digital data, digital voice, FM, and more coming on line every day. NVidia's CUDA platform was recently used to build a neural network that could interface with an RTL-SDR dongle (https://goo.gl/im4H8a)and can classify the signals it hears. The proof of concept has training to distinguish FM, SECAM, and tetra. However, you can train it to recognize other modulation schemes.

It isn't that big of a task to identify signals using your built-in neural network. However, this is a great example of a practical neural net and it does open the door to other possibilities. For example, automated monitoring of multiple channels would need something like this.

What else could you do with an intelligent radio? We've already seen a different kind of neural network decode Enigma traffic.

Voyager Spacecraft Communications

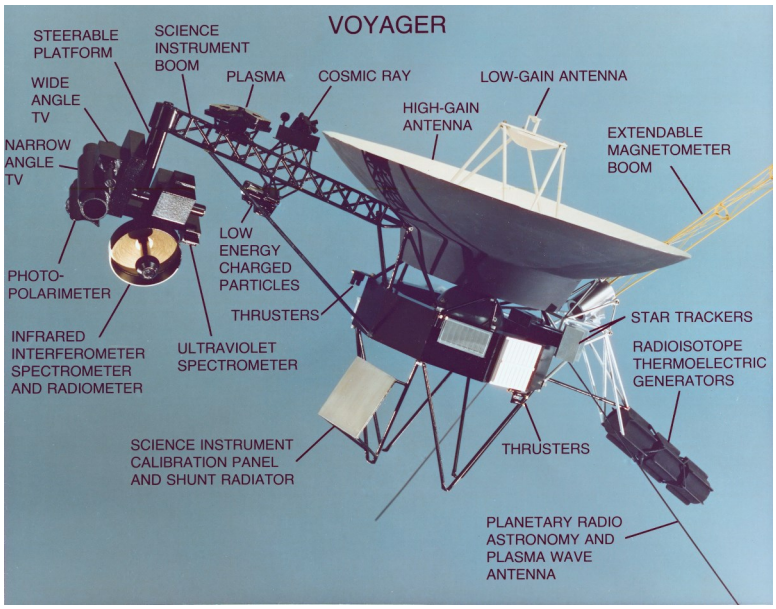


Table 1-1. Spacecraft lifetime estimates in calendar years.

	Voyager 1	Voyager 2
Electrical power	2023	2023
Telemetry link capability		
7200 bps, 70-/34-m HEF[a] array	1994	1998
1400 bps, 70-m antenna	2007	2011
600 bps, 70-m antenna	2026	2030
600 bps, 34-m HEF antenna	2003	2007
160 bps, 34-m HEF antenna	2024	2029
40 bps, 34-m HEF antenna	2050	2057
Hydrazine for attitude control	2040	2048

[a] High efficiency.

(Continued from page 3)

The low gain S-band antenna was also available for emergencies until the link margin was exhausted in the 1980s. These frequencies, especially the X band link, were selected because they are set aside for deep space communications and are protected worldwide against interference. The downlink from Voyager now only uses the X band link because of the higher link margin over S band. The radio on Voyager outputs 22W, which is basically the medium power setting on a modern mobile amateur radio!

The uplink to Voyager is via NASA's Deep Space Network (DSN) using S band. DSN consists of three stations - JPL in California; Canberra, Australia; and Madrid, Spain.

They normally transmit with 20kW of power. The station at Canberra has capabilities to use 400kW of power and is now the only station to communicate with the Voyager spacecraft on a regular basis. The Canberra transmitter is so powerful that airspace has to be shut down around the station when in operation at those power levels. The DSN receivers are kept cryogenically cooled to reduce receiver thermal noise to almost zero, increasing DSN receiver sensitivity. Receivers were upgraded in the 2000's improving link margin by about 1dB. DSN uses its 34m and 70m antennas, sometimes together to increase effective aperture, to receive Voyager data. At S-band, the 70m antennas have a gain of approximately 63dBi, and at X-band the gain is about 73dBi!

The most bandwidth intensive mission data were the pictures sent back from Jupiter, Saturn, Uranus, and Neptune. While at Jupiter and Saturn, the Voyagers used Golay encoding but did not use image compression. Error correcting codes were definitely required by the very low signal levels.

Surprisingly, the Voyagers also carried an experimental but more efficient Reed-Solomon encoder. R-S encoding is what compact discs and DVDs use for error correction This more efficient

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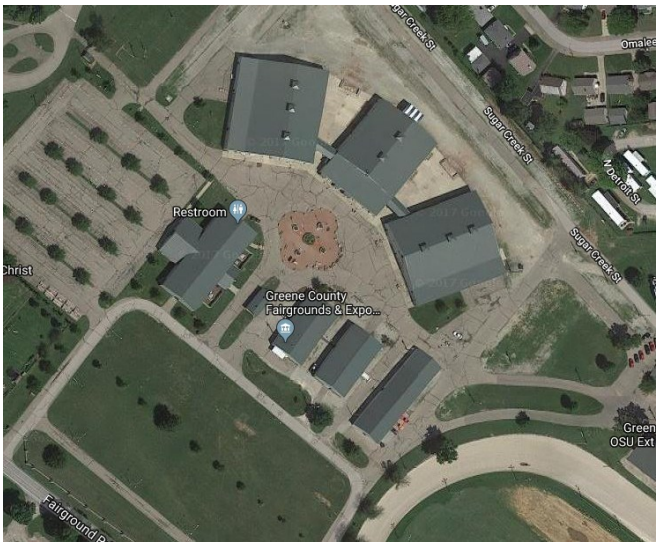
New Building Coming at Greene County Fairgrounds



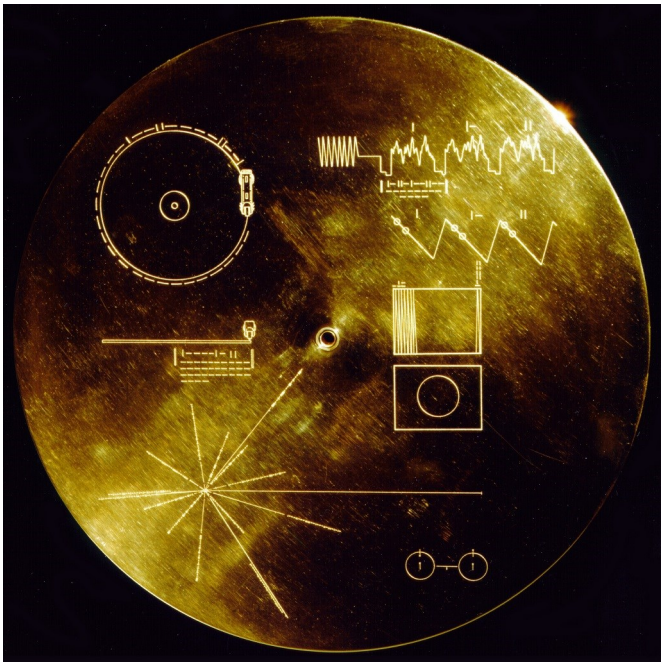
The Greene County Commissioners and the Greene County Fair Board have approved the construction of a new building at the Greene County Fairgrounds and Expo Center, the new Hamvention venue in Xenia, Ohio.

"Greene County officials have decided to move forward with construction of a new building, as it will continue to expand their presence in the region as a world-class Exposition Center," Hamvention Spokesperson Michael Kalter, W8CI, said in a news release. "Hamvention certainly benefits from the decision to expand the Expo Center footprint. Construction is planned to be complete ahead of Hamvention 2018, and [the new building] will be used for the event."

In addition to the new structure, another building on the property, previously known as Fairgrounds Furniture, is being vacated and will be available for use by Hamvention in May 2018. Additional details are forthcoming. Kalter said Hamvention has been told that the additional floor space will cover an area larger than the tents Hamvention used for some activities in 2017.

"Although this decision was made to expand opportunities at the Expo Center, Hamvention is grateful for the support Greene County, Xenia Township, and the city of Xenia," Kalter added.

Voyager Spacecraft Communications



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coding and error correction mechanism was used at Uranus and Neptune.

At about the same time in the mid 1980s, NASA also expanded its DSN capabilities by growing its 64m antennas into 70m antennas to increase the physical gain to support the Voyager missions. The mission at Neptune required the use of the Very Large Array in New Mexico to keep bit rates high enough (more later) to get picture data back.

So how hard is it to communicate with the Voyagers? It's somewhat hard to find reliable and updated information, but the received signal strength at the DSN stations is anywhere from

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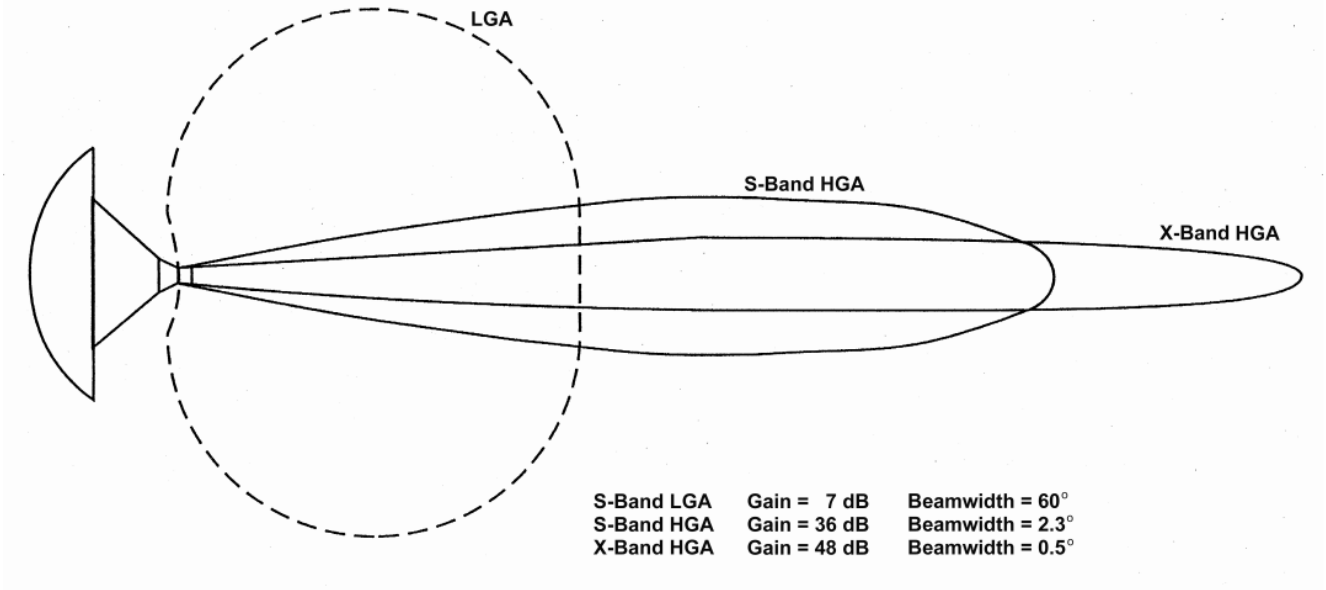
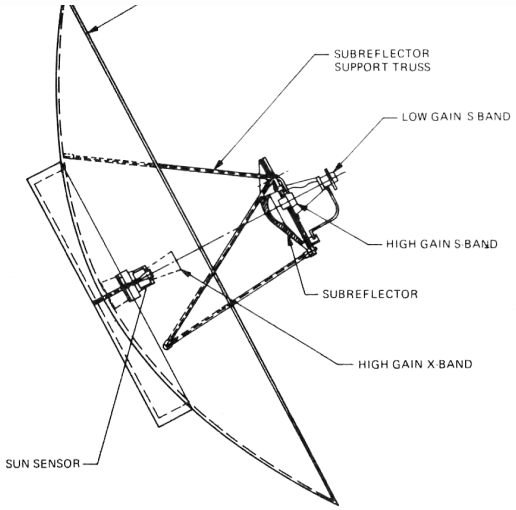
Voyager Spacecraft Communications





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10^(-16) to 10^(-20) (https://goo.gl/vpqvZR) Watts. That's -130dBm to -170dBm. Some sources (https://goo.gl/GiS6XW) claim the signal strength is as low as -245dBm or 10^(-28) Watts. By comparison, the received signal strength for amateur VHF repeater operations is typically in the -40dBm to -50dBm range. On the other side of the link, the Voyager spacecraft are receiving signals from DSN that are in the -120dBm (400kW transmit) to -130dBm (20kW transmit) range. And these signals have to be properly decoded on the Voyager using technology available in 1972! The saving grace is that the uplink command bit rate is only 16 bits per second (bps).

For mission data, bit rates started at about 115 kbps at Jupiter, or about twice the peak of phone modem capabilities in the late 1990s. If not for improvements in DSN, the bit rate would have dropped to 3.2kbps by Neptune. Instead, bit rates could be kept as high as 22kbps.

By the start of the interstellar mission, data rates had

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Bye, Bye Analog FM Radio

From The Local (https://goo.gl/E1FSG6)

Norway on Wednesday completed its transition to digital radio, becoming the first country in the world to shut down national broadcasts of its FM radio network.

As scheduled, the country's most northern regions and the Svalbard archipelago in the Arctic switched to Digital Audio Broadcasting (DAB) in the late morning, said Digitalradio Norge (DRN) which groups Norway's public and commercial radio.

The transition, which began on January 11th, allows for better sound quality, a greater number of channels and more functions, all at a cost eight times lower than FM radio, according to authorities.

The move has however been met with some criticism linked to technical incidents and claims that there is not sufficient DAB coverage across the country. In addition, radio users have complained about the cost of having to buy new receivers or adapters, usually priced around 100 to 200 euros.

Currently, fewer than half of motorists (49 percent) are able to listen to DAB in their cars, according to DRN figures.

According to a study cited by local media, the share of Norwegians who listen to the radio on a daily basis has dropped by 10 percent in one year, and public broadcaster NRK has lost 21 percent of its audience.

"It's a big change and we have to give listeners time to adapt to digital radio," the head of DRN, Ole Jørgen Torvmark, said in a statement. "After each shutdown (in a region), we noticed that the audience first dropped but then rose again," he added.

The transition concerns only national radio channels. Most local stations continue to broadcast in FM. Other countries like Switzerland, Britain and Denmark are due to follow suit in the coming years.

Voyager Spacecraft Communications

(Continued from page 8)

dropped to 7.2kbps. That data rate was sustained for a period of time by arraying the 70m ground antennas with the 34m ground antennas. When that no longer worked, Voyager had to dial back its data rate to 1.4kbps. At some point, another DSN upgrade allowed Voyager to transmit in suppressed carrier mode (all the energy goes into the modulation instead of carrier) buying another 2 years of link margin. As of late 2017, the link margin will only support a basic 160bps, which includes a subset of the science instruments and telemetry data.

Keeping the Voyager spacecraft running and performing all of this time has required ongoing inventiveness.

Early in the Voyager 2 mission, a problem oc-

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Changing Dayton Skyline

From Dayton Daily News (https://goo.gl/fJB9E9)

The Dayton skyline changed a bit this week when workers removed a large microwave tower from AT&T's 10-story downtown building.

The 65-foot steel tower stood for more than a half century in downtown above the AT&T building that opened in 1930 on Second Street near the Federal Building. The odd-looking tower constructed in 1959 has always been a part of popular drawings and photos of Dayton's skyline.

AT&T, or Bell System at the time, launched in the late 1940s a $40 million microwave radio-relay skyway, a network of microwave devices designed to transmit telephone and television signals nationwide from Los Angeles to New York City.

In January 1949, the midwest network of the Bell System, connecting Cleveland and Toledo with Buffalo, Detroit, Chicago, Milwaukee and St Louis, was connected with the eastern network which included Boston, New York, Philadelphia, Washington, D.C. and Richmond, according to Holly Hollingsworth, a spokesman with AT&T.

Hubs in Dayton, Columbus and Cincinnati were connected to the combined network at Toledo in October 1949. The first call on the nationwide system was placed in August 1951 and continued into the 1990s, according to the company.

Today, fiber optics that carry large amounts of bandwith and satellites have replaced the need for microwave relay. Most of AT&T's giant microwave towers across the U.S. have been abandoned as the company sold off most of the network in 1999.

Table 6-1. Voyager 2 ground system performance improvements.

Encounter	(DSN with 1979–1981 capability)			
	Inverse Square	Expected Rate (bps)	Achieved Maximum Rate (bps)	Factor of Improvement
Jupiter	1/1	115,200 (ref.)	115,200	—
Saturn	1/4	~29,000	44,800	×1.5
Uranus	1/13	~9,000	29,900	×3.3
Neptune	1/36	~3,200	21,600	×6.8

Voyager Spacecraft Communications

(Continued from page 9)

curred with both the primary and backup receivers. The radio system uses a tracking loop to account for frequency drift due to the varying thermal environment. The primary receiver failed first, and then the tracking loop in the backup failed requiring careful adjustments in transmitted frequency from Earth and monitoring the effect in the telemetry data before attempting to send commands.

As stated before, once the Saturn mission was over, the Voyager's had to switch over to R-S encoding and drop Golay encoding to keep the bit rate up and errors low. One of the big improvements at Uranus and Neptune was to implement image compression techniques to fit the same information into the same size pipe. The algorithm took advantage of the fact that there was a lot of black in the pictures and that cloud features were very often low contrast. The net effect was a 60% reduction in image size without greatly impacting quality.

Finally, once the Voyagers left their planetary mission and started their interstellar mission, there was a careful process of deciding what equipment to use and when to conserve power and avoid unnecessary wear and tear. For example, it was decided to run the X-band transmitter in its low power setting initially at the beginning of the interstellar mission because the link margin was sufficient, and extending the life of the transmitter was important (interstellar space was still predicted to be 20-25 years away at the end of the planetary mission).

This is just the tip of the iceberg. The Jet Propulsion Laboratory produced a report (https://goo.gl/mouajA) in the early 2000s detailing the Voyager communications system, which was used as the primary source for this article. If you're familiar with radio design, there is plenty of technical detail to study. JPL has also published reports (https://goo.gl/13A7up) on communications systems of other deep space spacecraft if you're interested.

Further Reading:

The Voyager team fires up thrusters (https://goo.gl/mnQsfG) on Voyager 1 not used since its Jupiter encounter to buy more time.

Voyager Mission Status page (https://goo.gl/wS2tZG)

How the Voyagers keep running (https://goo.gl/dij2r3)

Radio telescope image of the Voyager signal (https://goo.gl/oMXvYq) using the Very Long Baseline Array

Forty Years Later (https://goo.gl/uQcEU8). Voyagers only talk to Australia

Deep Space Network status page (https://goo.gl/n2C5ZY). See what NASA is talking to way out there!

A good synopsis (https://goo.gl/vpqvZR) on the Voyager communication problem from a technical perspective

Fate of the Voyagers (https://goo.gl/o3EMEp). A recent article from Space.com

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Wavelengths

Wavelengths is published monthly by the Xenia Weather Amateur Radio Net. Our meetings are currently held on the 2nd Monday of each month at **7:30 pm** at the Greene Memorial Hospital Auditorium. You can find additional information about our organization at www.xwarn.net . We welcome new and experienced Amateur operators and those interest in becoming an Amateur operator to attend our meetings.