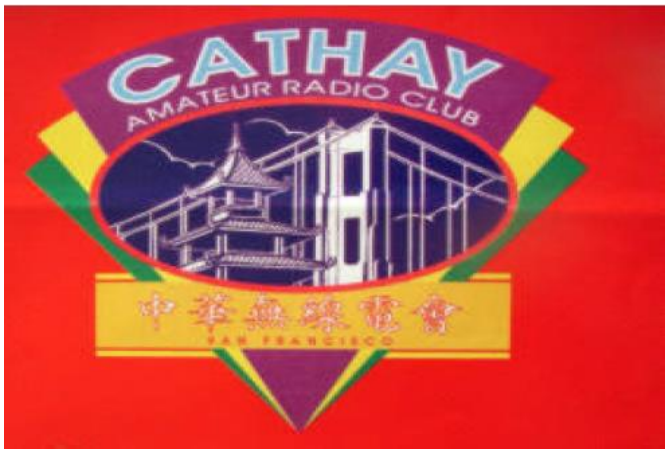


Cathay Dec 2020

www.cathayradio.org

President: George Chong, W6BUR **email:** *W6BUR@comcast.net*
Vice President North: Leonard Tom, *NX6E* **email:** nx6e@hotmail.com
Vice President South: Bill Fong, *W6BBA* - **email:** w6bba@arrl.net
Secretary/Membership: Rodney Yee, *KJ6DZI* - **email:** rodyee2000@yahoo.com
Editor: Rodney Yee, *KJ6DZI* - **email:** rodyee2000@yahoo.com
Treasurer: Vince Chinn aka Mingie, *W6EE* - **email:** vince@vincechinncpa.com
Web Master: Edison Fong – *WB6IQN* - **email:** edison_fong@hotmail.com
Mission: The Cathay Amateur Radio Club is basically an active social club of Ham Radio Operators and their spouses. We support local community requests for HAM emergency communications. Several of us are trained in CPR/ First Aid and are involved with community disaster preparedness.

Monday Night Net Time: 9 PM Local Time/PST, Repeater: WB6TCS - RX 147.210, TX 147.810, Offset +0.6 MHz, CTCSS/Tone PL100 Hz

Please note: Repeater: N6MNV UHF 442.700 Mhz, Offset +5MHz, CTCSS/Tone PL 173.8 Hz in South San Francisco is cross linked every Monday Night Net at 9 p.m. to WB6TCS 2-meter repeater.

The CARC Monday night net is the best way to find out the latest club news. All check-ins are welcome.

Message from the President: George Chong, *W6BUR*

Hello CARC Members and Friends;

Many thanks to Mr. Denis L. Moore – WB6TCS for the use of his repeater for our CARC Monday Night Net.

I wish to thank our CARC members that set aside their valuable time to participate in our Monday night's nets.

I hope you all had a peaceful Thanksgiving.

Yes, we have all managed to stumbled through the 2020 year and will be glad to be done with it in the next 31 days.

We all had to deal with COVID-19, huge financial market ups and down along with many forced business closures, unemployment, anxiously waiting for a COVID-19 vaccine, mask restrictions, curfews, BLM protest movement, looting, rioting, California wild fires, Hurricanes, and of course both the 2020 Presidential and Senate elections.

But through it all we had our weekly CARC nets and the comfort of our sense of community through our CARC club as an important stabilizing influence in our daily lives. Thank you all for being such dedicated CARC club members and being the "Best of The Very Best People" and that we could count each other when things looked bleak.

Hopefully we can get together in person in the near future once the COVID-19 vaccine program has successfully rolled out.

Having lived through and serviced in WWII, I always knew that Americans have shown a tremendous resiliency, resourcefulness, and that we could get through this COVID-19 pandemic together in one piece! In 2021, America will retake its leadership role on the world stage and prove it by having a rapid economic recovery and as we take care of each other.

Tech Article Introduction:

Tech Article #1: Many thanks to Ron Quan, KI6AZB for alerting me to the latest FCC ruling dated October 27, 2020 regarding Digital AM. Digital AM may obsolete all of the present AM radios unless the stations have a way to transmit dual AM/Digital modes.

Tech Article #2: The current update on the decommissioning of the Arecibo-Radio/Radar Telescope Observatory located in northern coast of Arecibo Puerto Rico. Often over looked is the observatory's radar capability to map the moon and planets in our solar system. Yes, it is of great lost to the scientific community.

Check out the two Tech Article for the full story.

Stay Safe and Stay Well, the end of COVID-19 is in sight.

Chat sub s'em to all you CARC members! - George W6BUR.

Public Service Announcements

HAM CRAM / HAM Licensing

For upcoming HAM Licensing locations please refer to:
http://www.arrl.org/find-an-amateur-radio-license-exam-session

Auxiliary Communications Service (ACS)

The Auxiliary Communications Service (ACS) was organized by the San Francisco Office of Emergency Services (OES) following the 1989 Loma Prieta Earthquake to support the communications needs of the City and County of San Francisco when responding to emergencies and special events.

The Auxiliary Communications Service holds General Meetings on the third Tuesday of each month at the San Francisco Emergency Operations Center, 1011 Turk Street (between Gough Street and Laguna Street), from 1900 hours to 2100 hours local time. All interested persons are welcome to attend.

The ACS Net begins at 1930 hours (7:30 p.m.) local time each Thursday evening, on the WA6GG repeater at 442.050 MHz, positive offset, tone 127.3 Hz. The purpose of this net is to practice Net Control skills, practice checking in with deployment status in a formal net, and to share information regarding upcoming ACS events. Guests are welcome to check in. ACS Members should perform Net Control duty on a regular basis. On the second Thursday of each month, the net will be conducted on the output frequency of the WA6GG repeater, 442.050 MHz no offset, tone 127.3 Hz, simplex.

For more information, please attend an ACS meeting or check in on a net, or call 415-558-2717.

Upcoming meetings: TBD

Gilbert Gin (KJ6HKD)

Free Disaster Preparedness Classes In Oakland:
http://www.oaklandnet.com/fire/core/index2.html

CORE is a free training program for individuals, neighborhood groups and community-based organizations in Oakland. The underlying premise is that a major disaster will overwhelm first responders, leaving many citizens on their own for the first 72 hours or longer after the emergency.

If you have questions about the recertification process, you may contact the CORE Coordinator at 510-238-6351 or core@oaklandnet.com.

Free Disaster Preparedness Classes In San Francisco – NERT Taught by San Francisco Fire Department (SFFD).

http://sf-fire.org/calendar-special-events

Upcoming events TBD

***SFFD DOT** is the Fire Department Division of Training. All participants walking, biking or driving **enter through the driveway gate on 19th St.** between Folsom and Shotwell. Parking is allowed along the back toward the cinderblock wall.

Visit ***www.sfgov.org/sffdnert*** to learn more about the training, other locations, and register on line. Upcoming Special NERT Events.

San Francisco Police Department: Auxiliary Law Enforcement Response Team (ALERT)

The Auxiliary Law Enforcement Response Team (ALERT) is a citizen disaster preparedness program designed. The ALERT program is for volunteers 16 years of age or older, who live, work, or attend high school in San Francisco.

Graduates of the San Francisco Police Activities League (P.A.L) Law Enforcement Cadet Academy are also eligible to join.

ALERT volunteers will no longer need to complete the Fire Department's Neighborhood Emergency Response Team (NERT) (www.sfgov.org/sfnert) training and then graduate into two 8 hour Police Department course specifically designed for ALERT team members.

ALERT members will work closely with full-time and/or Reserve Police Officers in the event they are deployed after a disaster. The Basic ALERT volunteer will have no law enforcement powers other than those available to all citizens.

SFPD ALERT Training (New Members)

The next SFPD ALERT training class has been scheduled for **TBD**. The class will be held at the San Francisco Police Academy, in the parking lot bungalow, from 8am-5pm (one hour lunch break) on Saturday.

* Class date indicated are only for new members

IMPORTANT- All participants must complete the background interview process in order to be eligible to attend the ALERT training class.

Eligible ALERT participants may register for a training class by contacting the ALERT Program Coordinator, Marina at sfpdalert@sfgov.org, or by telephone at 415-401-4615.

SFPD ALERT Practice/Training Drill

All active/trained ALERT members are asked to join us for our next training drill, scheduled for on **TBD** from 9 AM – 1pm. Details will be emailed to active ALERT members, prior to the date of the exercise. Participation is not required, but strongly encouraged.

For more information on the San Francisco Police Department ALERT Program, email us at sfpdalert@sfgov.org, or call Lt. Marina Chacon (SFPD Ret.), SFPD ALERT Program Coordinator, at (415) 401-4615.

For additional information on the web please refer to:
https://sfgov.org/policecommission/alert

Tech Article #1

https://docs.fcc.gov/public/attachments/DOC-367780A1.pdf

Media Contact:
Janice Wise, (202) 418-8165
janice.wise@fcc.gov

For Immediate Release

FCC AUTHORIZES ALL-DIGITAL AM RADIO

Action Will Improve Listening Experience and Provide Consumers with Enhanced Services

Washington, October 27, 2020—The Federal Communications Commission today adopted a Report and Order that allows AM radio stations to operate using all-digital broadcast signals. AM broadcasters will be able to voluntarily choose whether and when to convert to all-digital operation from their current analog or hybrid analog/digital signals

All-digital broadcasting offers AM listeners significantly improved audio quality and more reliable coverage over a wider listenable area than analog or hybrid digital broadcasts. It also allows broadcasters to provide additional services to the public, such as song title and artist information. These enhancements will enable AM broadcasters to better compete in today's media marketplace.

Today's Order establishes technical rules to protect existing AM broadcast stations from interference. In addition, stations converting to all-digital operation will be required to notify the Commission and the public 30 days in advance of their transition. These stations must provide at least one free over-the-air digital programming stream that is comparable to or better in audio quality than a standard analog broadcast. They also must continue to participate in the Emergency Alert System. The Order envisions that AM broadcasters will decide whether to convert to all-digital operation based on the conditions in their respective markets.

Action by the Commission October 27, 2020 by Report and Order (FCC 20-154). Chairman Pai, Commissioners O'Rielly, Carr, Rosenworcel, and Starks approving. Chairman Pai, and Commissioner Rosenworcel issuing separate statements.
MB Docket Nos. 19-311, 13-249

Media Relations: (202) 418-0500 / ASL: (844) 432-2275 / Twitter: @FCC / www.fcc.gov

This is an unofficial announcement of Commission action. Release of the full text of a Commission order constitutes official action. See MCI v. FCC, 515 F.2d 385 (D.C. Cir. 1974).

Tech Article #2

News Release 20-010

NSF begins planning for decommissioning of Arecibo Observatory's 305-meter telescope due to safety concerns

Arecibo Observatory's 305-meter telescope in November of 2020.

November 24, 2020

UPDATE: During ongoing aerial drone surveillance of the Arecibo Observatory's 305-meter telescope, engineers observed additional breakages on the exterior wires of the remaining cables attached to Tower 4. This is the same tower to which the failed auxiliary cable and the broken main cable were attached. Safety is NSF's top priority. As engineers continue their work on a safety plan for the 305-meter telescope decommissioning process, NSF will continue to assess the situation and use every available resource to determine a safe path forward.

November 19, 2020

Following a review of engineering assessments that found damage to the Arecibo Observatory cannot be stabilized without risk to construction workers and staff at the facility, the U.S. National Science Foundation will begin plans to decommission the 305-meter telescope, which for 57 years has served as a world-class resource for radio astronomy, planetary, solar system and geospace research.

The decision comes after NSF evaluated multiple assessments by independent engineering companies that found the telescope structure is in danger of a catastrophic failure and its cables may no longer be capable of carrying the loads they were designed to support. Furthermore, several assessments stated that any attempts at repairs could put workers in potentially life-threatening danger. Even in the event of repairs going forward, engineers found that the structure would likely present long-term stability issues.

"NSF prioritizes the safety of workers, Arecibo Observatory's staff and visitors, which makes this decision necessary, although unfortunate," said NSF Director Sethuraman Panchanathan. "For nearly six decades, the Arecibo Observatory has served as a beacon for breakthrough science and what a partnership with a community can look like. While this is a profound change, we will be looking for ways to assist the scientific community and maintain that strong relationship with the people of Puerto Rico."

Engineers have been examining the Arecibo Observatory 305-meter telescope since August, when one of its support cables detached. NSF authorized the University of Central Florida, which manages Arecibo, to take all reasonable steps and use available funds to address the situation while ensuring safety remained the highest priority. UCF acted quickly, and the evaluation process was following its expected timeline, considering the age of the facility, the complexity of the design and the potential risk to workers.

The engineering teams had designed and were ready to implement emergency structural stabilization of the auxiliary cable system. While the observatory was arranging for delivery of two replacement auxiliary cables, as well as two temporary cables, a main cable broke on the same tower Nov. 6. Based on the stresses on the second broken cable -- which should have been well within its ability to function without breaking -- engineers concluded that the remaining cables are likely weaker than originally projected.

"Leadership at Arecibo Observatory and UCF did a commendable job addressing this situation, acting quickly and pursuing every possible option to save this incredible

instrument," said Ralph Gaume, director of NSF's Division of Astronomical Sciences. "Until these assessments came in, our question was not if the observatory should be repaired but how. But in the end, a preponderance of data showed that we simply could not do this safely. And that is a line we cannot cross."

The scope of NSF's decommissioning plan would focus only on the 305-meter telescope and is intended to safely preserve other parts of the observatory that could be damaged or destroyed in the event of an unplanned, catastrophic collapse. The plan aims to retain as much as possible of the remaining infrastructure of Arecibo Observatory, so that it remains available for future research and educational missions.

The decommissioning process involves developing a technical execution plan and ensuring compliance with a series of legal, environmental, safety and cultural requirements over the coming weeks. NSF has authorized a high-resolution photographic survey using drones, and is considering options for forensic evaluation of the broken cable -- if such action could be done safely -- to see if any new evidence could inform the ongoing plans. This work has already begun and will continue throughout the decommissioning planning. Equipment and other materials will be temporarily moved to buildings outside the danger zone. When all necessary preparations have been made, the telescope would be subject to a controlled disassembly.

After the telescope decommissioning, NSF would intend to restore operations at assets such as the Arecibo Observatory LIDAR facility -- a valuable geospace research tool -- as well as at the visitor center and offsite Culebra facility, which analyzes cloud cover and precipitation data. NSF would also seek to explore possibilities for expanding the educational capacities of the learning center. Safety precautions due to the COVID-19 pandemic will remain in place as appropriate.

Some Arecibo operations involving the analysis and cataloging of archived data collected by the telescope would continue. UCF secured enhanced cloud storage and analytics capabilities in 2019 through an agreement with Microsoft, and the observatory is working to migrate on-site data to servers outside of the affected area.

Areas of the observatory that could be affected by an uncontrolled collapse have been evacuated since the November cable break and will remain closed to unauthorized personnel during the decommissioning. NSF and UCF will work to minimize risk in the area in the event of an unexpected collapse. NSF has prioritized a swift, thorough process with the intent of avoiding such an event.

NSF recognizes the cultural and economic significance of Arecibo Observatory to Puerto Rico, and how the telescope serves as an inspiration for Puerto Ricans considering education and employment in STEM. NSF's goal is to work with the Puerto Rican government and other stakeholders and partners to explore the possibility of applying resources from Arecibo Observatory for educational purposes.

"Over its lifetime, Arecibo Observatory has helped transform our understanding of the ionosphere, showing us how density, composition and other factors interact to shape this critical region where Earth’s atmosphere meets space," said Michael Wiltberger,

head of NSF's Geospace Section. "While I am disappointed by the loss of investigative capabilities, I believe this process is a necessary step to preserve the research community's ability to use Arecibo Observatory's other assets and hopefully ensure that important work can continue at the facility."

Engineering summary

Arecibo Observatory's telescope consists of a radio dish 1,000 feet (305 meters) wide in diameter with a 900-ton instrument platform hanging 450 feet above. The platform is suspended by cables connected to three towers.

On Aug. 10, 2020, an auxiliary cable failed, slipping from its socket in one of the towers and leaving a 100-foot gash in the dish below. NSF authorized Arecibo Observatory to take all reasonable steps and use available funds, which amounted to millions of dollars, to secure the analysis and equipment needed to address the situation. Engineers were working to determine how to repair the damage and determine the integrity of the structure when a main cable connected to the same tower broke Nov. 6.

The second broken cable was unexpected -- engineering assessments following the auxiliary cable failure indicated the structure was stable and the planning process to restore the telescope to operation was underway. Engineers subsequently found this 3-inch main cable snapped at about 60% of what should have been its minimum breaking strength during a period of calm weather, raising the possibility of other cables being weaker than expected.

Inspections of the other cables revealed new wire breaks on some of the main cables, which were original to the structure, and evidence of significant slippage at several sockets holding the remaining auxiliary cables, which were added during a refit in the 1990s that added weight to the instrument platform.

Thornton Tomasetti, the engineering firm of record hired by UCF to assess the structure, found that given the likelihood of another cable failing, repair work on the telescope -- including mitigation measures to stabilize it for additional work -- would be unsafe. Stress tests to capture a more accurate measure of the remaining cables' strength could collapse the structure, Thornton Tomasetti found. The firm recommended a controlled demolition to eliminate the danger of an unexpected collapse.

"Although it saddens us to make this recommendation, we believe the structure should be demolished in a controlled way as soon as pragmatically possible, " said the recommendation for action letter submitted by Thornton Tomasetti. "It is therefore our recommendation to expeditiously plan for decommissioning of the observatory and execute a controlled demolition of the telescope."

UCF also hired two other engineering firms to provide assessments of the situation. One recommended immediate stabilization action. The other, after reviewing Thornton Tomasetti's model, concurred that there is no course of action that could safely verify the structure's stability and advised against allowing personnel on the telescope's platforms or towers.

“Critical work remains to be done in the area of atmospheric sciences, planetary sciences, radio astronomy and radar astronomy,” UCF President Alexander N. Cartwright said. “UCF stands ready to utilize its experience with the observatory to join other stakeholders in pursuing the kind of commitment and funding needed to continue and build on Arecibo’s contributions to science.”

After receiving the contracted assessments, NSF brought in an independent engineering firm and the Army Corps of Engineers to review the findings. The firm NSF hired concurred with the recommendations of Thornton Tomasetti and expressed concern about significant danger from uncontrolled collapse. The Army Corps of Engineers recommended gathering additional photographic evidence of the facility and a complete forensic evaluation of the broken cable.

Given the fact that any stabilization or repair scenario would require workers to be on or near the telescope structure, the degree of uncertainty about the cables' strength and the extreme forces at work, NSF accepted the recommendation to prepare for controlled decommissioning of the 305-meter telescope.

Engineering assessments from the companies contracted by UCF are available online:

Thornton Tomasetti recommendation for course of action at Arecibo Observatory

WSP recommendation for future efforts at Arecibo Observatory

WJE memorandum on Arecibo Observatory stabilization efforts

-NSF-

Media Contacts
Media Affairs, NSF, (703) 292-7090, email: media@nsf.gov

The U.S. National Science Foundation propels the nation forward by advancing fundamental research in all fields of science and engineering. NSF supports research and people by providing facilities, instruments and funding to support their ingenuity and sustain the U.S. as a global leader in research and innovation. With a fiscal year 2020 budget of $8.3 billion, NSF funds reach all 50 states through grants to nearly 2,000 colleges, universities and institutions. Each year, NSF receives more than 40,000 competitive proposals and makes about 11,000 new awards. Those awards include support for cooperative research with industry, Arctic and Antarctic research and operations, and U.S. participation in international scientific efforts.

Additional information on the Arecibo Observatory courtesy of Wikipedia:

https://en.wikipedia.org/wiki/Arecibo_Observatory

Arecibo Observatory

From Wikipedia, the free encyclopedia

Jump to navigation Jump to search

Arecibo Observatory

Alternative names	National Astronomy and Ionosphere Center
Named after	Arecibo
Location(s)	Arecibo, Puerto Rico, Caribbean
Coordinates	18°20′48″N 66°45′10″WCoordinates: 18°20′48″N 66°45′10″W

Organization	Ana G. Méndez University National Science Foundation University of Central Florida
Altitude	498 m (1,634 ft)
First light	November 1, 1963
Decommissioned	Announced November 19, 2020
Telescope style	astronomical observatory visitor center
Website	www.naic.edu

Location of Arecibo Observatory

National Astronomy and Ionosphere Center

U.S. National Register of Historic Places

U.S. Historic district

Nearest city	Arecibo
Area	118 acres (48 ha)
Architect	Gordon, William E; Kavanaugh, T. C.
Engineer	von Seb, Inc., T. C. Kavanaugh of Praeger-Kavanagh, and Severud-Elstad-Krueger Associates[1]

NRHP reference No. 07000525

Added to NRHP September 23, 2008[2]

Related media on Wikimedia Commons

The **Arecibo Observatory** is an observatory in Arecibo, Puerto Rico, also known as the **National Astronomy and Ionosphere Center** (**NAIC**). It is owned by the US National Science Foundation (NSF). The main instrument of the observatory is the Arecibo Telescope, a 305 m (1,000 ft) spherical reflector dish built into a natural sinkhole, a cable-mount steerable receiver mounted 150 m (492 ft) above the dish, and several radar transmitters for emitting signals. For more than 50 years, the Arecibo Telescope was the world's largest single-aperture telescope, surpassed in July 2016 by the Five-hundred-meter Aperture Spherical Telescope (FAST) in China. The Observatory also includes a radio telescope, a Lidar facility, and a visitor's center.

The Arecibo Telescope was primarily used for research in radio astronomy, atmospheric science, and radar astronomy, as well as for programs that search for extraterrestrial intelligence (SETI). Scientists wanting to use the observatory submitted proposals that were evaluated by independent scientific referees. NASA has also used the telescope for near-Earth object detection programs. The observatory, funded primarily by the National Science Foundation (NSF) with partial support from NASA, was managed by Cornell University from its completion in 1963 until 2011, after which it was transferred to a partnership led by SRI International. In 2018, a consortium led by the University of Central Florida assumed operation of the facility.

The telescope's unique and futuristic design led to several appearances in film, gaming and television productions, such as for the climactic fight scene in the 1995 James Bond film *GoldenEye*. It has been listed on the US National Register of Historic Places since 2008.[2][3] The center was named an IEEE Milestone in 2001.[4] It has a visitor center that is open part-time.[5]

Since 2006, the NSF has reduced its funding commitment to the observatory, leading academics to push for additional funding support to continue its programs. The telescope was damaged by Hurricane Maria in 2017 and was affected by earthquakes in 2019 and 2020. Two cable breaks, one in August 2020 and a second in November 2020, threatened the structural integrity of the support structure for the suspended platform and damaged the dish. Due to uncertainty over the remaining strength of the other cables supporting the suspended structure, and the risk of collapse due to further failures making repairs dangerous, the NSF announced on November 19, 2020, that it would decommission and dismantle the telescope, with the radio telescope and LIDAR facility remaining operational.[6][7][8]

General information

The main collecting dish has the shape of a spherical cap 1,000 feet (305 m) in diameter with an 869-foot (265 m) radius of curvature,[9] and is constructed inside a karst sinkhole.[10] The dish surface is made of 38,778 perforated aluminum panels, each

about 3 by 7 feet (1 by 2 m), supported by a mesh of steel cables.[9] The ground beneath supports shade-tolerant vegetation.[11]

The observatory has three radar transmitters, with effective isotropic radiated powers (EIRPs) of 25 TW (continuous) at 2380 MHz, 3.2 TW (pulse peak) at 430 MHz, and 200 MW at 47 MHz,[12] as well as an ionospheric modification facility operating at 5.1 and 8.175 MHz.[13]

The dish remains stationary, while receivers and transmitters are moved to the proper focal point of the telescope to aim at the desired target.[14] As a spherical mirror, the reflector's focus is along a line rather than at one point. As a result, complex line feeds were implemented to carry out observations, with each line feed covering a narrow frequency band measuring 10–45 MHz. A limited number of line feeds could be used at any one time, limiting the telescope's flexibility.[9]

The receiver is on an 820-tonne (900-short-ton) platform suspended 150 m (492 ft) above the dish by 18 cables running from three reinforced concrete towers, one 111 m (365 ft) high and the other two 81 m (265 ft) high, placing their tops at the same elevation. The platform has a rotating, bow-shaped track 93 m (305 ft) long, called the azimuth arm, carrying the receiving antennas and secondary and tertiary reflectors. This allows the telescope to observe any region of the sky in a forty-degree cone of visibility about the local zenith (between −1 and 38 degrees of declination). Puerto Rico's location near the Northern Tropic allows Arecibo to view the planets in the Solar System over the northern half of their orbit. The round trip light time to objects beyond Saturn is longer than the 2.6-hour time that the telescope can track a celestial position, preventing radar observations of more distant objects.[10][*failed verification*]

The observatory also has other facilities beyond the main telescope, including a 12 metres (39 ft) radio telescope used for VLBI,[15] and a LIDAR facility.[6]

The Arecibo Radio Telescope as viewed from the observation deck, October 2013

History

Design and construction

A detailed view of the beam-steering mechanism. The triangular platform at the top is fixed, and the azimuth arm rotates beneath it. To the right is the Gregorian sub-reflector, and to the left is the remains of the 96-foot-long (29 m) line feed tuned to 430 MHz (destroyed by Hurricane Maria). Also to the right is the catwalk and part of the rectangular waveguide that brings the 2.5 MW 430 MHz radar transmitter's signal up to the focal region.

The origins of the observatory trace to late 1950s efforts to develop anti-ballistic missile (ABM) defenses as part of the newly formed ARPA's ABM umbrella-effort, Project Defender. Even at this early stage it was clear that the use of radar decoys would be a serious problem at the long ranges needed to successfully attack a warhead, ranges on the order of 1,600 km (1,000 mi).[16][17]

Among the many Defender projects were several studies based on the concept that a re-entering nuclear warhead would cause unique physical signatures while still in the upper atmosphere. It was known that hot, high-speed objects caused ionization of the atmosphere that reflects radar waves, and it appeared that a warhead's signature would be different enough from decoys that a detector could pick out the warhead directly, or alternately, provide added information that would allow operators to focus a conventional tracking radar on the single return from the warhead.[16][17]

Although the concept appeared to offer a solution to the tracking problem, there was almost no information on either the physics of re-entry or a strong understanding of the normal composition of the upper layers of the ionosphere. ARPA began to address both simultaneously. To better understand the radar returns from a warhead, several radars were built on Kwajalein Atoll, while Arecibo started with the dual purpose of understanding the ionosphere's F-layer while also producing a general-purpose scientific radio observatory.[16][17]

The observatory was built between mid-1960 and November 1963. William E. Gordon of Cornell University oversaw its design for study of the Earth's ionosphere.[18][19][20][21] He was attracted to the sinkholes in the karst regions of Puerto Rico that offered perfect cavities for a very large dish.[22][23][24] Originally, a fixed parabolic reflector was envisioned, pointing in a fixed direction with a 150 m (492 ft) tower to hold equipment at

the focus. This design would have limited its use in other research areas, such as radar astronomy, radio astronomy and atmospheric science, which require the ability to point at different positions in the sky and track those positions for an extended time as the Earth rotates. Ward Low of the Advanced Research Projects Agency (ARPA) pointed out this flaw and put Gordon in touch with the Air Force Cambridge Research Laboratory (AFCRL) in Boston, Massachusetts, where one group headed by Phil Blacksmith was working on spherical reflectors and another group was studying the propagation of radio waves in and through the upper atmosphere. Cornell University proposed the project to ARPA in mid-1958 and a contract was signed between the AFCRL and the University in November 1959. Cornell University and Zachary Sears published a request for proposals (RFP) asking for a design to support a feed moving along a spherical surface 133 metres (435 ft) above the stationary reflector. The RFP suggested a tripod or a tower in the center to support the feed. On the day the project for the design and construction of the antenna was announced at Cornell University, Gordon had also envisioned a 133 m (435 ft) tower centered in the 305 m (1,000 ft) reflector to support the feed.[25][26][27]

George Doundoulakis, who directed research at General Bronze Corporation in Garden City, New York, along with Zachary Sears, who directed Internal Design at Digital B & E Corporation, New York, received the RFP from Cornell University for the antenna design and studied the idea of suspending the feed with his brother, Helias Doundoulakis, a civil engineer. George Doundoulakis identified the problem that a tower or tripod would have presented around the center, (the most important area of the reflector), and devised a better design by suspending the feed.[19][18] He presented his proposal to Cornell University for a doughnut or torus-type truss suspended by four cables from four towers above the reflector, having along its edge a rail track for the azimuthal truss positioning. This second truss, in the form of an arc, or arch, was to be suspended below, which would rotate on the rails through 360 degrees. The arc also had rails on which the unit supporting the feed would move for the feed's elevational positioning. A counterweight would move symmetrically opposite to the feed for stability and, if a hurricane struck, the whole feed could be raised and lowered. Helias Doundoulakis designed the cable suspension system which was finally adopted. Although the present configuration is substantially the same as the original drawings by George and Helias Doundoulakis, (although with three towers, instead of the original four as drawn in the original patent), the U.S. Patent office granted Helias Doundoulakis a patent,[28][29] The idea of a spherical reflecting mirror with a steerable secondary has since been used in optical telescopes, in particular, the Hobby–Eberly Telescope[30] and the Southern African Large Telescope.[31]

Construction began in mid-1960, with the official opening on November 1, 1963.[32]

Upgrades

Since then, the telescope has been upgraded several times. Initially, when the maximum expected operating frequency was about 500 MHz, the surface consisted of half-inch galvanized wire mesh laid directly on the support cables. In 1973, a high-precision surface consisting of 38,000 individually adjustable aluminum panels replaced the old wire mesh,[33] and the highest usable frequency rose to about 5000 MHz. A

Gregorian reflector system was installed in 1997, incorporating secondary and tertiary reflectors to focus radio waves at one point. This allowed installing a suite of receivers, covering the full 1–10 GHz range, that could be easily moved to the focal point, giving Arecibo more flexibility. A metal mesh screen was also installed around the perimeter to block the ground's thermal radiation from reaching the feed antennas. Finally, a more powerful 2400 MHz transmitter was added.[34]

Panoramic view of the Arecibo radio telescope primary dish

Funding reductions

The Astronomical Sciences and Atmospheric Sciences divisions of the NSF had financially supported Arecibo since its completion in the 1970s, with incremental support by NASA, for operating the planetary radar.[35] Between 2001 and 2006, NASA decreased, then eliminated, its support of the planetary radar.[36]

A November 2006 report by the Astronomical Sciences division recommended substantially decreased astronomy funding for the Arecibo Observatory, from US$10.5 million in 2007 to US$4.0 million in 2011. The report further stated that if other sources of funding could not be found, closure of the Observatory was recommended.[37][38]

Academics and researchers responded by organizing to protect and advocate for the observatory. They established the Arecibo Science Advocacy Partnership (ASAP) in 2008, to advance the scientific excellence of Arecibo Observatory research and to publicize its accomplishments in astronomy, aeronomy and planetary radar as to seek additional funding support for the observatory.[39] An additional US$3 million in bonds were secured from the government of Puerto Rico.[40][41] Academics, media and influential politicians pressured the United States Congress on the importance of the work of the observatory.[42][43] led to additional US$3.1 million in funding to support Arecibo in the American Recovery and Reinvestment Act of 2009. This was used for basic maintenance and for a second, much smaller, antenna to be used for very long baseline interferometry, new Klystron amplifiers for the planetary radar system and student training.[44]

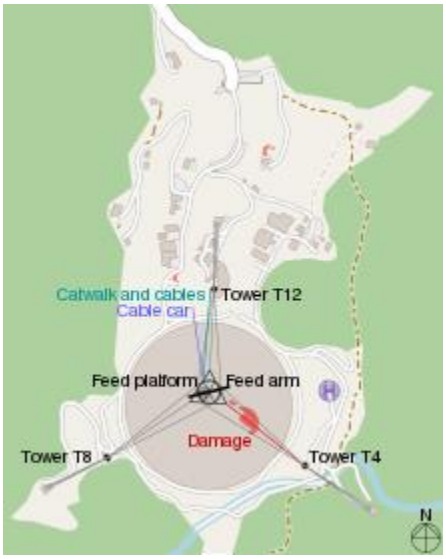
Arecibo's budget from NSF continued to wane in the following years.[45][46] Starting in FY2010, NASA restored its historical support by contributing $2.0 million per year for planetary science, particularly the study of near-Earth objects, at Arecibo. NASA

implemented this funding through its Near Earth Object Observations program.[47] NASA increased its support to $3.5 million per year in 2012.

In 2011, NSF removed Cornell University, which had managed NAIC since the 1970s, as the operator and transferred these responsibilities to SRI International, along with two other managing partners, Universities Space Research Association and Universidad Metropolitana de Puerto Rico, with a number of other collaborators.[48][49] NSF also decertified NAIC as a Federally Funded Research and Development Center (FFRDC), which the NSF said would give NAIC greater freedom to establish broader scientific partnerships and pursue funding opportunities for activities beyond the scope of those supported by NSF.[46][50]

While the Observatory continued to operate under the reduced NSF budget and NASA funds, NSF signaled in 2015 and 2016 that it was looking towards potential decommissioning of the Observatory by initiating environmental impact statements on the effect of deconstructing the unit.[51] The NSF continued to indicate it would like to reduce funding to the Observatory in the near future.[52][53] As in 2008, academics expressed their concern over the loss of scientific discoveries that could occur should the Observatory be shut down.[51]

2020 damage and decommissioning



Map of Arecibo Observatory after November 2020 cable damage [54]

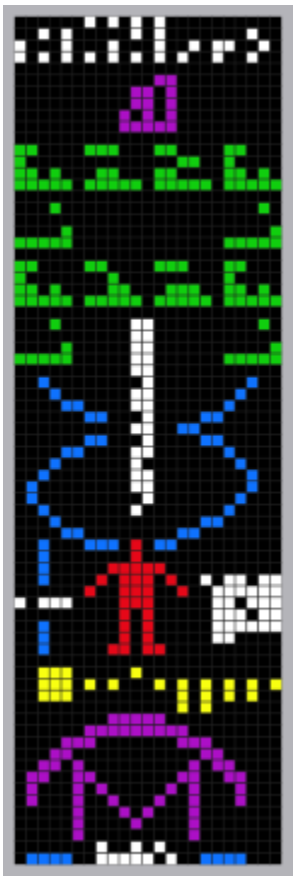
Several hurricanes and storms over the 2010s had raised the concerns of structural engineers over the stability of the observatory.[55] On September 21, 2017, high winds associated with Hurricane Maria caused the 430 MHz line feed to break and fall onto the primary dish, damaging roughly 30 of the 38,000 aluminum panels. Most Arecibo observations do not use the line feed but instead rely on the feeds and receivers located in the dome. Overall, the damage inflicted by Maria was minimal,[56][57][58][59] but it further clouded the observatory's future. Restoring all the previous capabilities required more than the observatory's already-threatened operating budget, and users feared the

decision would be made to decommission it instead.[60] A consortium consisting of the University of Central Florida (UCF), Yang Enterprises and UMET, came forward to supply funding in February 2018 to allow the NSF to reduce its contribution towards Arecibo's operating costs from $8 million to $2 million from the fiscal year 2022–2023, thus securing the observatory's future.[61] With this, the UCF consortium were named the new operators of the observatory in 2018.[62][63]

On August 10, 2020, a platform support cable broke, causing damage to the telescope, including a 100 ft (30 m) gash in the reflector dish.[64][65] No one was reported to have been hurt by the partial collapse. The facility had recently reopened following the passing of Tropical Storm Isaias. It was not clear if the cable failure was caused by Isaias. Damage included six to eight panels in the Gregorian Dome, and to the platform used to access the dome. The facility was closed as damage assessments were made.[66]

NSF had ordered a replacement cable to replace the broken one, but on November 7, 2020, before the new cable could be installed, a second cable broke, shattering part of the dish itself.[67] The engineering staff that had been monitoring the cables, as well as additional support from the U.S. Army Corps of Engineers, evaluated the remaining cables and made the determination that there was no way to safely repair the damage at this point, as the remaining cables could all be suspect,[68][69] and a controlled decommissioning of the telescope was the only effective answer to avoid catastrophic failure that would threaten the other buildings near the dome.[70] One engineering firm proposed stabilization efforts.[71] The NSF made the announcement on November 19, 2020 that they will decommission Arecibo in the next few weeks after determining the safest route to do so with a safety exclusion zone immediately put in place.[72] NSF's Sean Jones stated, "This decision is not an easy one for NSF to make, but safety of people is our number one priority." The lidar facility will remain operational.[55][6]

Research and discoveries



The Arecibo message with added color to highlight the separate parts. The actual binary transmission carried no color information.

Many scientific discoveries were made with the observatory. On April 7, 1964, soon after it began operating, Gordon Pettengill's team used it to determine that the rotation period of Mercury was not 88 days, as formerly thought, but only 59 days.[73] In 1968, the discovery of the periodicity of the Crab Pulsar (33 milliseconds) by Lovelace and others provided the first solid evidence that neutron stars exist.[74] In 1974, Hulse and Taylor discovered the first binary pulsar PSR B1913+16,[75] an accomplishment for which they later received the Nobel Prize in Physics. In 1982, the first millisecond pulsar, PSR B1937+21, was discovered by Donald C. Backer, Shrinivas Kulkarni, Carl Heiles, Michael Davis, and Miller Goss.[76] This object spins 642 times per second and, until the discovery of PSR J1748-2446ad in 2005, was identified as the fastest-spinning pulsar.

In August 1989, the observatory directly imaged an asteroid for the first time in history: 4769 Castalia.[77] The following year, Polish astronomer Aleksander Wolszczan made the discovery of pulsar PSR B1257+12, which later led him to discover its three orbiting planets.[78] These were the first extrasolar planets discovered. In 1994, John Harmon used the Arecibo Radio Telescope to map the distribution of ice in the polar regions of Mercury.[79]

In January 2008, detection of prebiotic molecules methanimine and hydrogen cyanide were reported from the observatory's radio spectroscopy measurements of the distant starburst galaxy Arp 220.[80]

From January 2010 to February 2011, American astronomers Matthew Route and Aleksander Wolszczan detected bursts of radio emission from the T6.5 brown dwarf 2MASS J10475385+2124234. This was the first time that radio emission had been detected from a T dwarf, which has methane absorption lines in its atmosphere. It is also the coolest brown dwarf (at a temperature of ~900K) from which radio emission has been observed. The highly polarized and highly energetic radio bursts indicated that the object has a >1.7 kG-strength magnetic field and magnetic activity similar to both the planet Jupiter and the Sun.[81]

The Arecibo message

Main article: Arecibo message

In 1974, the Arecibo message, an attempt to communicate with potential extraterrestrial life, was transmitted from the radio telescope toward the globular cluster Messier 13, about 25,000 light-years away.[82] The 1,679 bit pattern of 1s and 0s defined a 23 by 73 pixel bitmap image that included numbers, stick figures, chemical formulas and a crude image of the telescope.[83]

SETI and METI projects

Main articles: SETI and Active SETI

Search for extraterrestrial intelligence (SETI)[84] is the search for extraterrestrial life or advanced technologies. SETI aims to answer the question "Are we alone in the Universe?" by scanning the skies for transmissions from intelligent civilizations elsewhere in our galaxy.

In comparison, METI (messaging to extraterrestrial intelligence) refers to the active search by transmitting messages.

Arecibo is the source of data for the SETI@home and Astropulse distributed computing projects put forward by the Space Sciences Laboratory at the University of California, Berkeley, and was used for the SETI Institute's Project Phoenix observations.[85] The Einstein@Home distributed computing project has found more than 20 pulsars in Arecibo data.[86]

Other uses

Terrestrial aeronomy experiments at Arecibo have included the Coqui 2 experiment, supported by NASA. The telescope also originally had military intelligence uses, including locating Soviet radar installations by detecting their signals bouncing off the Moon.[87]

Limited amateur radio operations have occurred, using *moon bounce* or Earth–Moon–Earth communication, in which radio signals aimed at the Moon are reflected back to Earth. The first of these operations was on June 13–14, 1964, using the call KP4BPZ. A dozen or so two-way contacts were made on 144 and 432 MHz. On July 3 and 24, 1965, KP4BPZ was again activated on 432 MHz, making approximately 30 contacts on 432 MHz during the limited time slots available. For these tests, a very wide-band instrumentation recorder captured a large segment of the receiving bandwidth, enabling later verification of other amateur station callsigns. These were not two-way contacts. From April 16–18, 2010, again, the Arecibo Amateur Radio Club KP4AO conducted moon-bounce activity using the antenna.[88] On November 10, 2013, the KP4AO Arecibo Amateur Radio Club conducted a Fifty-Year Commemoration Activation, lasting seven hours on 14.250 MHz SSB, without using the main dish antenna.[89]

Ángel Ramos Foundation Visitor Center

Logo of the observatory at the entrance gate

Opened in 1997, the Ángel Ramos Foundation Visitor Center features interactive exhibits and displays about the operations of the radio telescope, astronomy and atmospheric sciences.[90] The center is named after the financial foundation that honors Ángel Ramos, owner of the *El Mundo* newspaper and founder of Telemundo. The Foundation provided half of the funds to build the Visitor Center, with the remainder received from private donations and Cornell University.

The center, in collaboration with the Caribbean Astronomical Society,[91] host a series of Astronomical Nights throughout the year, which feature diverse discussions regarding exoplanets, and astronomical phenomena and discoveries (such as Comet ISON). The main purpose of the center is to increase public interest in astronomy, the observatory's research successes, and space endeavors.

List of directors

Source(s):[92][*additional citation(s) needed*]

- 1960–1965: William E. Gordon
- 1965–1966: John W. Findlay
- 1966–1968: Frank Drake
- 1968–1971: Gordon Pettengill
- 1971–1973: Tor Hagfors[93]

- 1973–1982: Harold D. Craft Jr.[94]
- 1982–1987: Donald B. Campbell
- 1987–1988: Riccardo Giovanelli
- 1988–1992: Michael M. Davis
- 1992–2003: Daniel R. Altschuler [es]
- 2003–2006: Sixto A. González
- 2006–2007: Timothy H. Hankins
- 2007–2008: Robert B. Kerr[95]
- 2008–2011: Michael C. Nolan
- 2011–2015: Robert B. Kerr[95]
- 2016–present: Francisco Córdova

In popular culture

Due to its unique shape and concept, the observatory is featured in many contemporary works. It was used as a filming location in the films *GoldenEye* (1995), *Species* (1995), and *Contact* (1997) (based on Carl Sagan's novel of the same name which also featured the observatory),[96][97] and in *The X-Files* television episode "Little Green Men".[98] In 2014, a video art installation piece titled *The Great Silence* by artists Jennifer Allora and Guillermo Calzadilla in collaboration with science fiction writer Ted Chiang featured the radio telescope at Arecibo Observatory to represent the search for extraterrestrial life. The juxtaposed text was later published as a short story with the same title in a special issue of the art journal *e-flux* in 2015 and was included in the author's short story collection *Exhalation: Stories* in 2019.[99]