A Big Change in my Career

Jeff Beish

MY YEARS WITH RADIO TELESCOPES

Located about 20 miles southwest of Miami, Florida was the U.S. Naval Observatory Time Service Alternate Station (NOTSAS). The station was established in 1949 by Paul Sollenberger, the U. S. Naval Observatory's first civilian Director of Time Service and is located next to the grounds of an old WW-I & II blimp station, and the Dade County Metro Zoo. Part of the old blimp hanger is still there and used by the fire department for training. When I first worked for the USNO, Dr. Gart Westerhout (1977 - 1993) - https://aas.org/obituaries/gart-westerhout-1927-2012-0 was the Scientific Director of the USNO and Dr. Gernot M. R. Winkler (1965 – 1997) - https://baas.aas.org/pub/gernot-maria-rudolph-winkler-1922-2016-5/release/1 was Director of Time Service and was replaced by Dr. Demetrios Matsakis in 1997. Dr. Kenneth J. Johnston became Scientific Director of the USNO (1993 – 2012). Don Monger was the USNO-NOTSAS director; however, he was replaced by Jim Martin when Don retired.

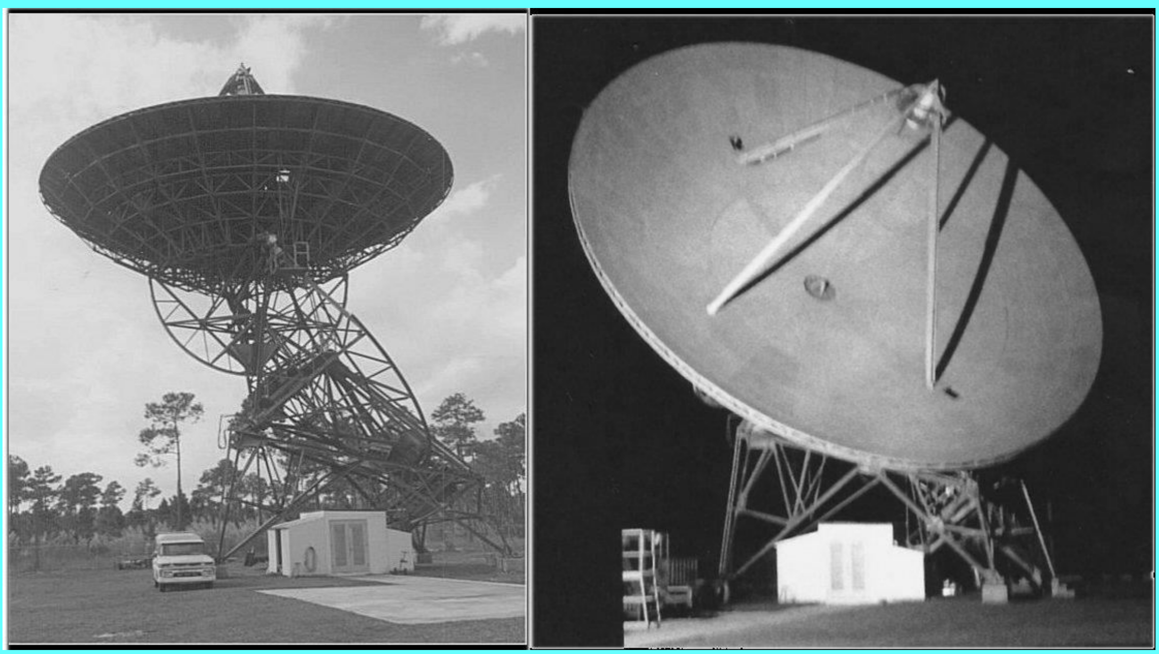
I was an amateur astronomer before my time at the USNO and at that time the station had a staff of seven people attached with the Navy and one technician with NOAA. We had three astronomers, one mathematician, a technician, and an engineer, or technician depending of which hat I wore on that particular day. When I began at the USNO Time Service Station Alice Babcock (1987 – 1990) was the station Director who was later transferred to the Flagstaff Station and was replaced by Timothy S. Carroll (1991 – 1996). The station employees were: Ron Medford (Assistant Director), Melvin White (mathematician), Ron Anderkitus (astronomer and time keeper), Ed Luckas (Technician), Mike Mooney (astronomer) who resigned in 1995, Jim Sweeney (NGS) who retired in December 1989 and was replaced by Greg DeAngelo (NOAA), and me (USNO).

Our primary mission was to supply the United States Navy with "Atomic Time" in case the primary time service station in Washington, DC failed. We had an appropriate number of "atomic clocks" (Cesium Clocks) and hydrogen masers (a maser is a very accurate hydrogen based oscillator) and several computers to record time data and compute the average 1-second pulses from all the clocks and masers.

Our secondary mission was to work with a worldwide network of radio telescopes to provide Very Long Baseline Interferometry (VLBI) data. Located on our station was an 18-meter radio telescope that was literally found in a junkyard near another radio observatory in Massachusetts. VLBI operations began in January 1989 (similar dish at: https://en.wikipedia.org/wiki/Mullard_Radio_Astronomy_Observatory). The name of the station was changed a few times from "Alternate Station" to "Sub-Station" then, well; we never quite caught up with the changes before it closed. We thought it was appropriate to call it "Sub-station" because the superintendent of the USNO at that time was a former Submarine commander!

The Former U.S. Naval Observatory Time Service Alternate Station (NOTSAS) as It Appears Today.

A silly side note: After our director was observing one night she heard a gun shot and a bang in the direction of the dish. After we inspected the dish we found 21 bullet holes in it. Guess some people who stay up late at night get bored.



The old 18-meter radio dish as it looked in 1989 before the hurricane. A night shot.

My duties included maintenance and service of the satellite antenna transmitter and receiver systems and Global Positioning Satellite (GPS) systems working in conjunction with satellite time transfer systems (See: Two-Way Satellite Time Transfer. I was assigned additional duties for collecting and analysis of ground water level measuring and local meteorological conditions including software and hardware development for our "Gravimeter," a machine to record the relative gravity in the local area. It was a strange tank with super conducting coils to stabilize the actual measuring instrumentation and was cooled by a helium Dewar system to around 4 Kelvin.

3.7-meter dish and 2-meter dish

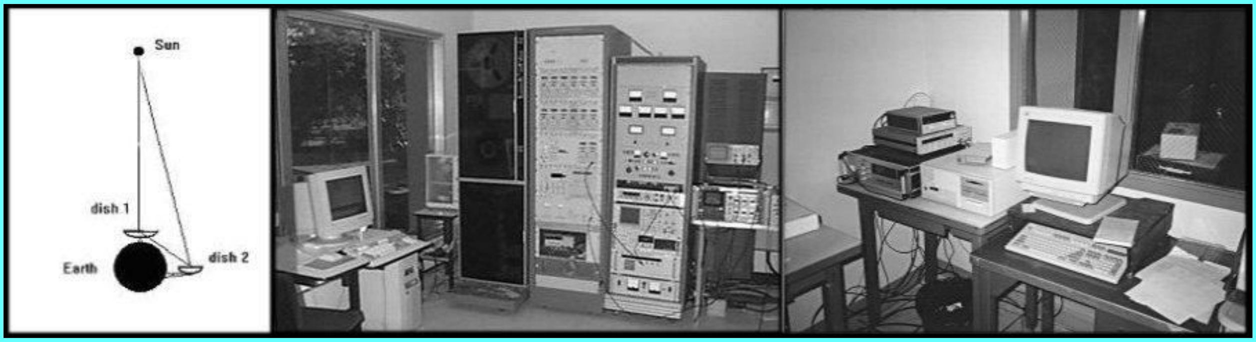
I installed and operated two satellite antennas for 2-way time transfers with USNO in Washington. Also, I was required to design software for automated control of precise time transfer and calculations between our station and the U.S. Naval Observatory Time Station in Washington, D.C., and several other time service stations around the world. We had a 4.6-meter antenna before the hurricane, but replaced it with a 3.7-meter dish and also a 2-meter dish.

SIMULTANEOUS OBSERVING

Radio waves, or electromagnetic energy, are radiated by all matter in our Universe above absolute zero (zero Kelvin) and we can detect it in most cases. All objects that emit energy can be measured and the frequency of the emissions depends on what level of energy the object is radiating. So, while not going too deeply into Einstein's theories in this matter (sic), we must understand one principle used in radio astronomy that is similar to optical astronomy -- electromagnetic energy waves in the radio frequencies follow the same basic rules as optical systems. From these radio-emitting objects the radio telescope, or dish, collects radio energy similarly to the way a lens or mirror collects light energy. The difference is that the human eye, film, or other light sensitive gadgets (CCD) receive this light energy and radio telescopes require a radio receiver. However, that is getting too deep already, so let's talk about something more down to Earth. What is it like to be a radio telescope operator and fixer' upper.

VLBI is accomplished by using not one radio dish, but in concert with several other dishes located around the world that is equipped with the same, or nearly same, recording devices and electronics to translate the radio data. The electronics systems combine the hydrogen masers pulses and cesium clock (atomic clock) data with the radio data on magnetic tape. If a standard time scale and accurate timing system can be connected to each radio dish, synchronized to the same time, then it is possible to coordinate many different telescopes to observe and record the same information on a magnetic tape or other modern recording medium. Most often we would operate simultaneously with three or more, sometimes as many as eight dishes to observe the same object (see Figure below)!

Continental drift and surface levels also can be determined by using radio telescopes that are grouped together but separated by long distances. If we stationed one dish on Earth directly under the Sun and the other at the Earth's limb, an oblique triangle is formed. Energy is measured in both systems at the same time; the angle can be used to determine the distance between telescopes. For eight years this author worked with a radio telescope (dish) to determine such mundane phenomena as the rotation of the Earth, tilt and wobble of the Earth's axis, highly stable pulses from millisecond pulsars, high energy galaxies, quasars, and so on.



Two radio telescopes pointed at the Sun and separated 90 degrees. One is directly under the Sun and the other at the limb or edge of Earth form an oblique triangle. Center&Right is typical VLBI control room.

Radio astronomy is among the most technical subjects we can talk about. It falls in somewhere between futuristic and ancient technology and is not easily explained to the general amateur astronomy public. Articles relating to the nuts and bolts of radio telescopes rarely appear in the popular amateur astronomical press, so amateur participating in radio astronomy is even less popular. Also, the technology involved can be very expensive and requires some knowledge in electronics. Technical articles are more suited for trained scientists and technologists so we must keep it as simple as possible in this paper.

A complex radio receiver is used to detect and convert the radio signals to a more usable form for recording on magnetic tape. Our receiver operated in the S-Band (2,000 Megahertz) and X-Band (8,000 Megahertz) and converted to an IF frequency band of 100-600 Megahertz. This data is further reduced in frequency to video frequencies for the recording tape.

A cryogenics helium compressor system is used to cool the receiver pickup and front-end amplifiers to a cool 20 Kelvin! That is -423 degrees Fahrenheit! This involved several hundred feet of stainless steel piping (plumbing) and a helium compressor that provides helium gas to a tank and compressor system called a Dewar; special insulated tank with receiver and its electronics. The very low temperature provided by the Dewar enables the reviver to operate without appreciable noise.

The recordings are made using 9,000-foot reels of magnetic tape with 14 tracks to make high-speed recordings. Several miles of data is recorded each pass the tape makes on the recorder. In fact, in a 24-hour observing period will result in 1,720 miles of data! The tape recorder utilizes a special read and write head system that can be moved by a few micrometers (microns) to provide 24 passes across the tape -- forward and reverse. Up to eight different telescopes operating simultaneously provides us enough data to reach over half way around the Earth in just in 24 hours. You can bet the next generation of higher speed tape recording devices will yield enough data to wrap the complete circumference of the Earth several times over.

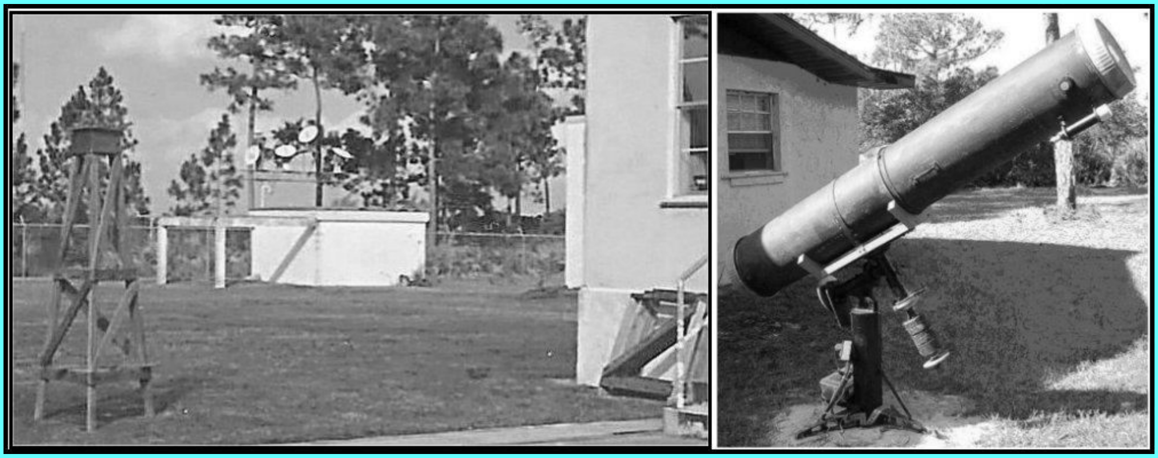
OPERATING A DISH MONSTER

Many of the dish drive and associated electronics are located within the pier and about 100 feet away in the control room that contained the tape unit and main computer systems. The entire operation was controlled by two desktop computers in the control room and directed the inputs/outputs to slew the dish and track objects to be recorded and then set in motion the various systems that would convert the radio electromagnetic information to magnetic tape data. One of the computers was connected to the Internet via broadband and protected routers that enabled outside stations to communicate with our system.

Before the old dish was replaced the observatory staff would draw straws, so to speak, for operating the scheduled 24-hour observing sessions. We would split the sessions up into four shifts where the midnight shift ran from midnight until 8 a.m. and two 8-hour shifts during the day. Operating during the day was fairly easy since we would remain at our workstations and continue our regular duties and attend to the scheduled sessions periodically to check on things. The old 18-meter dish was old and not exactly trustworthy, so when it would stop driving or a computer would glitch we would all jump into action to fix the problem. During the nightshift we would find a few moments to sleep, but at times the old dish would not allow much relaxation. Also, if the regular maintenance guy (me) was not on duty I would be called to come help -- at any time of the day or night.

Much of the observing period was uneventful where the operator would monitor the computer screens, electronics panels and tape unit for proper operation. Three tape reels were used throughout the session so the operator would swap reels in a few minutes to keep up with the schedule. At times a walk around the grounds to inspect the dish and equipment was necessary. Occasionally the dish would stop driving or the electronics would malfunction, so the operator or technician would step in to solve the problem. Electronic systems had to be calibrated or tuned during a session and to make sure the clock systems were operating properly to be recorded along with the receiver signals.

An additional advantage for an active Mars observer was during the night shift operating sessions this observer would stay close to the control room with a 12.5-inch f/7 Newtonian telescope and observe the Red Planet as long as I wished. This scope was setup at the observatory site for other observing staff to use as well, and several coworkers participated in the observing sessions. Whenever a national astronomy day or similar event would take place the USNO would open to the public and staff would help with public observing with my telescope and the station telescopes. The station had a 15’x15’ roll-off-roof observatory for either a 6” astrograph telescope or C11 telescope.

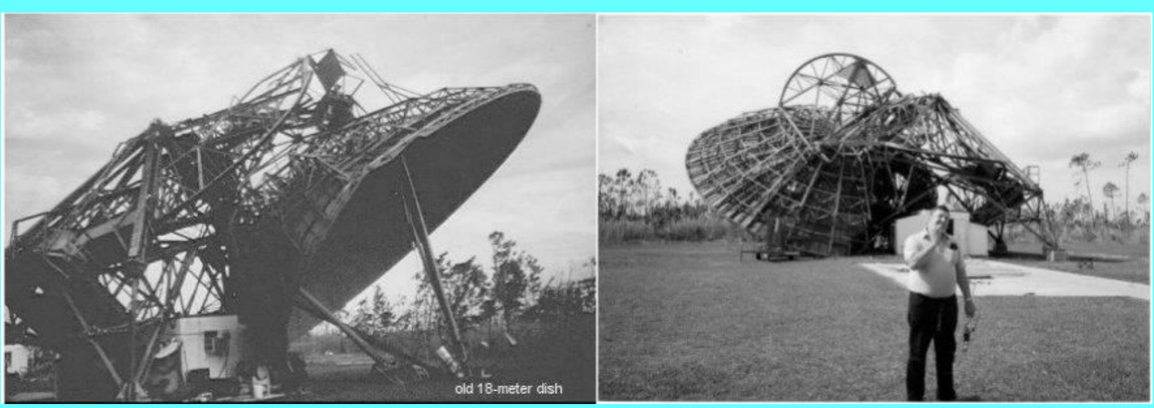


USNO Roll-off-roof observatory and 12.5" f/7 Telescope

I attended the January 1990 annual meeting of the American Astronomical Society representing NOTAS with Alice Babcock. Also, I participated in the Lowell International Planetary Patrol at Mauna Kea, Hawaii from October 29 through November 8, 1990. While there I made thousands of photographs of Mars using my camera and thousands with the Patrol Camera (See: International Planetary Patrol).

Hurricane Andrew

On August 24, 1992, Category 5 hurricane Andrew damaged the USNO station and destroyed the old 18-meter radio telescope. The dish was knocked down and completely destroyed by winds of over 200 MPH. Repairs began in about a year and after two years of repairs to the station we finally received the new 20-meter f/0.4 prime focus radio telescope from TIW Systems Inc, Sunnyvale, California. During September 1994 Tim and I traveled to Sunnyvale, CA to look at a new 20-meter radio telescope dish to replace the 18-meter dish. Work on the station continued throughout 1994 and 1995 while the 20-meter dish was being assembled. By the second week of May 1995 the radio receiver arrived and after we installed it the telescope began operation in the fall of 1995. That was my primary duty -- to manage the radio astronomy maintenance and operation. Prior to the hurricane we had removed the receiver for storage and later shipped to a company in Maryland for service and modifications.

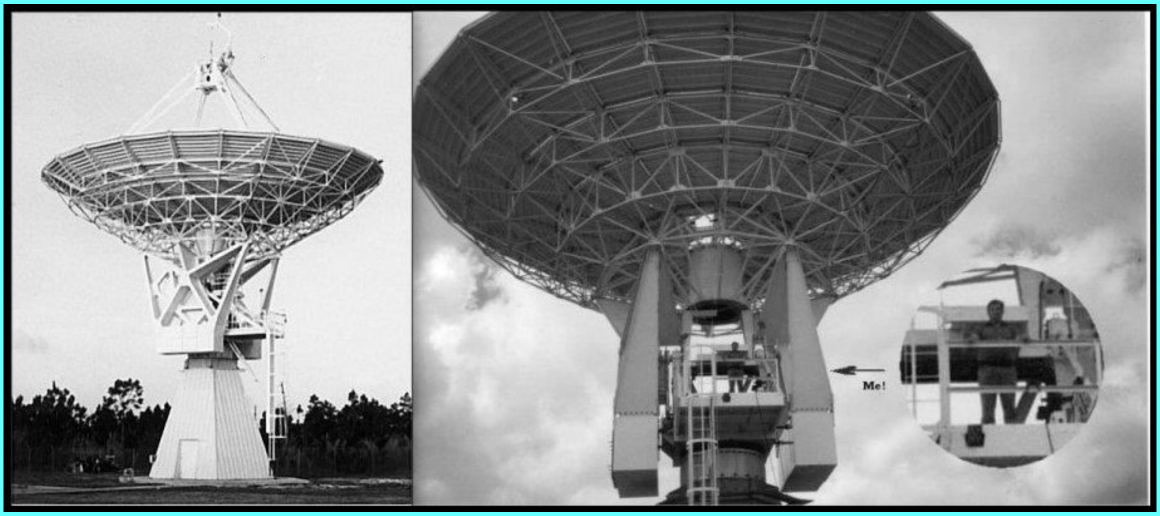


An after hurricane Andrew version of the old 18-meter radio dish. Winds of over 200 MPH knocked this dish down and then it was pointing in an odd direction. These radio dishes were used in the VLBI projects of NASA, JPL, USNO, and many other observatories.

To watch the construction of the main pier and foundation was fascinating to say the least. The base was a 40-foot octagon shaped, 4-foot deep slab of concrete. Over 168 yards of concrete and 1.5-inch rebar was used to make the octagon shaped slopping pier that stood 25 feet high and with 18-inch thick walls. After pier was finished the company, who made the dish, brought in a team of workers and a 225-ton crane to lift the parts into place. The dish alone weighed over 50,000 pounds. Our counterweight was 88,000 pounds of steel scrap and concrete with an additional 6,000 of removable steel plates.

UPPERLEFT: Rebar and concrete framing to form 25-foot high pier for radio telescope. UPPERRIGHT: A 225-ton crane lifts elevation and azimuth mount assemblies onto concrete pier. LOWERLEFT: 50,000-pound dish lifted onto the mount. LOWERRIGHT: The weight of the dish bending the crane boom 7 feet.

The 800-pound receiver is housed in a water-tight box located in a cage atop the four support arms or "quadropod." Interestingly the receiver is cooled by solid state cooling devices. To reach the cage one would simply climb 30 feet up into the dish drive motor platform, then 20 more feet up into the dish and walk out to the edge of the dish where one of the support arms had hand and foot peddles. The foot peddles would enable us to climb the support arm then reach the receiver cage. Occasionally the receiver would require maintenance that could not be done up at the 85-foot level, so we used the maintenance crane to lift the entire box down to ground level. That was fun because we had to attached the box to the crane and unbolt it, lift it a few feet, then turn the dish 90 degrees and let the box down to the ground.



LEFT: the new 20-meter radio telescope. The driver electronics and computer systems located in the pier. Another maintenance technician and this engineer spent many hours in that pier! RIGHT: Me looking down from the motor platform.

A mix up in communications resulted in a minor error in the amount of counterweights we needed, so we had to calculate the over balance and remove some of the large, and heavy, steel plates. Needless to say this was no easy task, for each weighed 75 pounds and handling these plates 25 feet up can give one some anxious moments! Of course, maintaining such a system can be hazardous and time consuming -- but exciting as well. To sit up at 85 feet and look out at the ocean some 5 miles away is beneficial in several ways. First, there are no telephones up there, and second, you are not inclined to come down too soon after the climb up -- keeps the weight down.

USNO Station in Miami, Florida, control room on top left. Backup Generator Building and Two-Way Satellite Dish. Bottom: USNO Station Front View

The new dish was a great relief to the maintenance people because it was more reliable than the old dish and required less attention. Modern desktop computers (PC) made all the decisions for slewing and tracking the objects under study and running all the associated electronics. The Internet connection enabled other agencies to view data or modify controlling software when necessary. As engineer and maintenance technician one of my tasks was to establish remote control from the staff homes using commercial remote control software. This enabled observers to stay at home for the midnight shift sessions and would be alerted by automatic telephone call if a problem came up. This method proved successful because we lost no observation periods after that. In fact this system made it possible for the maintenance people to remotely analyze problems and fix them if possible using our personal computers at home. Other functions of the station, such as the two-way satellite time transfers, could be remotely controlled. This proved to work very well and several computer programs were created to completely automate the system.

A major problem came up when we noticed that the receiver outputs were unstable when the dish was slewed quickly from one target to another. This had gone undetected throughout the initial equipment acceptance by the Navy and after VLBI observations had been in operation for a year. This technician then noticed that the quadropod legs were warping and vibrating when the dish stopped slewing; causing the receiver to tumble for a few seconds. Software changes were made to dampen these oscillations; however, the requirements for quick target acquisition were necessary to keep the VLBI schedule operating and the situation was never resolved. Apparently the quadropod arms were not strong enough to take the inertial of the target acquisition motion.

Another major problem cropped up with the cryogenics system piping (plumbing) from the first stage compressor to the receiver Dewar compressor that had to be resolved before proper cooling of the receiver could be maintained and operations could continue. The main compressor is located in the pier and aluminum tubes and flexible hoses pipe helium up 85 feet to the receiver on top of the quadropod arms. The flexible aluminum hoses began to leak Helium from holes caused by corrosion in the material, so the Dewar temperature would rise too high for proper receiver operation. Apparently this was caused by a chemical reaction between the material and Helium, so the entire piping system had to be replaced at considerable expense.

During the time from after Andrew until September 1996 I installed and operated two satellite antennas for 2-way time transfers with USNO in Washington. We had a 4.6-meter Andrew antenna before the storm, but replaced it with a 3.7-meter dish and also a 2-meter dish.

THE STATION IS CLOSED

By August of 1994 our mathematician and programmer had retired; followed by the deputy director who retired a few months later. The Navy (USNO) then decided to move the time service system to Falcon Air Force Base, Colorado Springs, Colorado and to be completed in November of 1995 (https://timeandnavigation.si.edu/multimedia-asset/us-naval-observatory-alternate-master-clock). One technician transferred to Washington, DC in May 1996 and our time keeper retired in July 1996. By then the station manpower was down to three Navy civilians and one NOAA technician. Our time service operations stopped in the spring of 1996 and all we had left was the VLBI operations with the radio telescope.

On July 4th, 1996 lightening hit near the telescope and damaged the drive electronics and replacing the cryogenics piping problem had to be resolved. We did not have parts to repair the damage or replace the pipes and our fait was sealed. The radio telescope began to deteriorate and repairs became impossible with no operational funds for parts. During July 1996 we were notified that the USNO Station was closing and they gave us a choice to either; retire, resign or transfer up to the U.S. Naval Observatory in Washington, DC. Having twice been given similar choices it was clear at my age that a transfer was in order. The grounds and radio dish equipment was turned over to the Center for Southeastern Tropical Advanced Remote Sensing (CSTARS) (https://www.rsmas.miami.edu/research/centers/cstars/index.html).

After living in the Miami area for over 24 years we finally left for the northeast. As of September 1996 I had only 4 years and 5 months away from retirement, so we moved south of Washington in Virginia and I reported to work at the U.S. Naval Observatory Time Service Engineering department on September 15, 1996.

NOTICE: Received an e-mail from Raymond Turner, Principal Systems Engineer - CSTARS, that the 20-meter dish was being disassembled and stored away until it can be sold to another party.



The 50,000 pound 20-meter dish being disassembled. The 40-foot octagon shape, 4-foot deep slab and 25 feet high and with 18-inch thick wall pier.

U.S. NAVAL OBSERVATORY IN WASHINGTON, D.C.

The USNO Time Service department was small and located on the second floor of the Time Service building (#78) and staffed by nine engineers and one mathematician-computer specialist. My coworkers were: Paul Wheeler (Chief of Dept), Tony Kubik, Angela (Davis) McKinley, Jim Eler, Phu Mai, George Luther, Jim DeYoung, Minh Tran and me. My duties required me to design software and hardware for automated control of precise time transfer and calculations between the U.S. Naval Observatory Time Station in Washington, D.C. and several other time service stations around the world. Our primary remote station was the USNO alternate time service at Schriber (Falcon) Air Force Base, Colorado. Their job was to supply precise time pulses to the Air Force GPS systems and to coordinate their atomic time with the master time in Washington. My duties also included design, construction and maintenance of the Two-Way Satellite Time Transfer systems and the maintenance and control of environmental chambers for HP5071A Cesium Clock and Microsemi MHM 2010 Hydrogen Maser at both locations.


Arial Views of USNO, Washington, DC

With the previous experience in automating the radio telescope control and Two-Way Satellite Time Transfer systems at the Miami Station I then applied similar applications in automating the entire time transfer systems at USNO. We communicated with time services all other the world and also with several research institutions in Europe and the Far East. USNO Engineering personnel were required tor travel to several locations to service, modify and install equipment used it all our operations around the world. I would regularly fly out to Schreiber or Vandenberg Air Force Bases to perform routine maintenance and modifications to the equipment there.

LEFT: U.S. Naval Observatory Time Service building 78. RIGHT: Two of the dishes used for Two-Way Satellite Time Transfer systems located next to the building 78 and 26-inch telescope dome in the distance.

At the USNO in Washington we had clock vaults, environmental chambers, located in several places on the USNO grounds. Each location contained 25 to 50 Cesium clocks, several hydrogen masers and electronic monitoring systems. Systems reported via USNO Intranet to the main time service building that input into several computer systems. Programs to compute accurate time was used to steer remote clock systems and keep them up with the master clock and backup master clock.

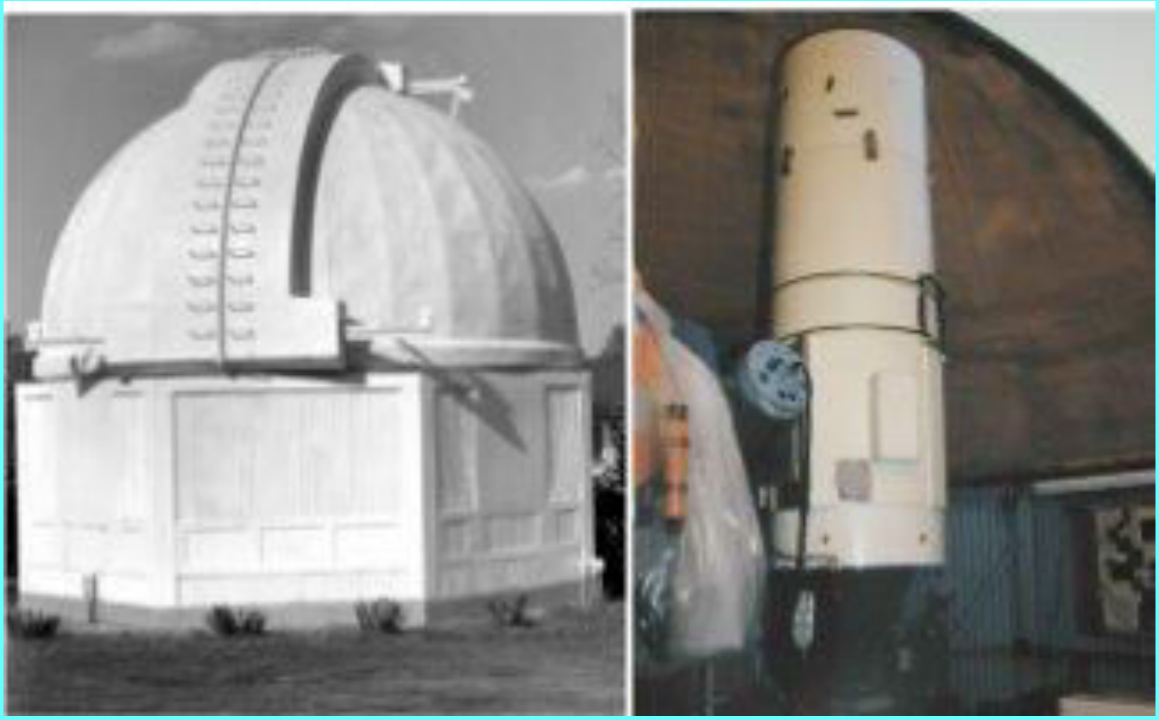
LEFT: Cesium Clocks in several small environmental chambers. RIGHT: Cesium Clocks in one of the larger environmental chambers.

Caught in the act of performing the real duties of a Real-Time Frequency Engineer at work. Additional work included mopping up leaking cooling water from environmental chambers.

We had remote time systems located all over the world and my tiny office housed several control systems to communicate and coordinate operations with other government agencies that used GPS, Loran and other navigational aids. Two-Way Satellite Time Transfers were made with many of the U.S. Air Force and Navy bases where precise time was needed. This modern method of keeping track of the various clock systems located throughout the world proved very useful in tracking and maintaining the required one nanosecond precision balance of time between the Navy's national time service and other clocks.

During the years from August 1996 my participating in astronomical meetings became less frequent and numerous. However, continuing my astronomy interests I participated in observing programs at the observatory occasionally with our mathematician, Jim DeYoung, using the 12-inch, 26-inch Clark refractors and a 24-inch Cassegrain. Jim and I would observe Mars using these telescopes before and/or after duty hours; however, as an employee of the Federal Government I hesitated in sending my reports to ALPO and other amateur organizations for obvious reasons. So my observations of Mars during the 1996-97, 1998-99 and early 2000-01 apparitions are not published.

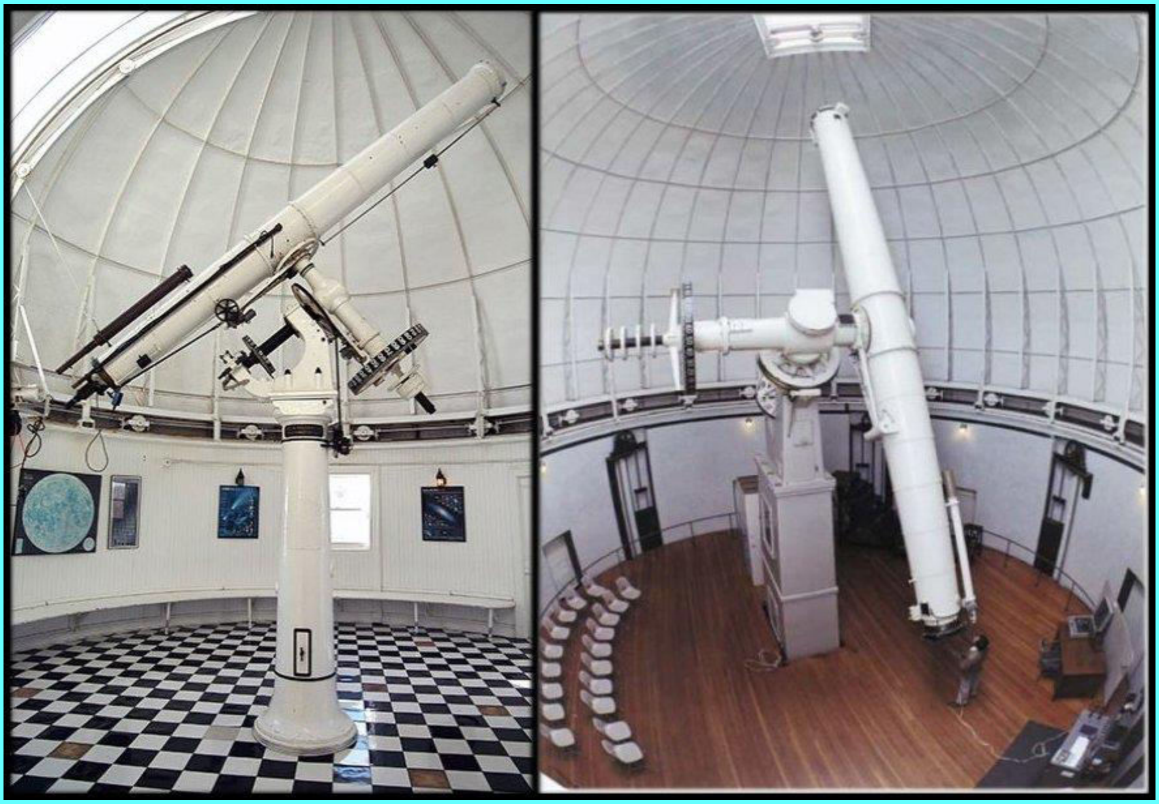
The engineering department was responsible to maintaining the telescope electronics and electrical systems, so we would test and repair anything that needed fixing. Some of the electrical wiring was so old it was literally falling apart and the electronic telescope drive systems predated my entry into the electronics field in 1960! The newest telescope, a 24-inch Boller and Chivens Cassegrain, had a 1960's era drive system and parts for it were hard to find. The other telescopes were 19th century vintage and maintenance was a nightmare to say the least.



USNO 24-inch dome and Boller & Chevens 24" Cassegrain Reflector

I attended several star parties with one of the USNO astronomers, Brent Archinal, which was sponsored by the local astronomy society. Meeting in a dark, grassy field at Crockett Park south of Manassas, Virginia I became friends with local amateur astronomer, Myron Wasiuta, of Fredricksberg, VA. The Northern Virginia Astronomy Club (NOVAC) sponsored a monthly star party and a couple of the NOVAC Star Party and Telescope Meets.

The U.S. Naval Observatory in Washington, DC. Image 1 is the dome on the main USNO administration building with 12-inch Clark Refractor. Image 2 is the 12-inch Clark telescope. Image 3 is the dome of the 26-inch Clark refractor.



LEFT: USNO 12-inch Clarke Refractor, RIGHT: USNO 26-inch Clark Refractor both used by Time Service amateurs to observe Mars.

Summary

By the time of my retirement I had Completed ***Electronic Engineering Technology*** with ***Capital Radio Engineering Institute (CREI)*** and the ***University of Maryland*** Extension courses in 1967 and then continued with Capital Radio Engineering Institute (CREI)/***New York Institute of Technology (NYIT)*** at Broome Technical Community College, Binghamton, NY majoring in ***Electronics Engineering, Science for Computer Control Systems and Electronic Control.*** I completed the ***Telescopic Astronomy, Coast Navigational School of Astronomy***, a correspondence course**.** In 1982 I Graduated from ***Observational Astronomy***, classes at the ***Florida International University (FIU*** Also, Protégé and understudy of the late Charles F. Capen, internationally recognized authority on Mars, I worked with him as my sponsor for a Doctoral of Science Degree (equivalency Ph.D).

Certificate from the Coast Navigational School of Astronomy, Telescopic Astronomy Course

NOTE: The ***Capitol Radio Engineering Institute (CREI)*** changed its name to the ***Capitol Institute of Technology*** (***CIT***) in 1964, and in 1987 to ***Capitol College*** and during 2014 assumed the name: ***Capitol Technology University***. They began as a correspondence school, like many others, advertising in the back of Popular Mechanics. Unlike the others, in 1932 they opened a residence hall and hands-on classes. By 1966 they were offering genuine bachelors degrees. In 1969 they moved to Kensington, Maryland then in 1980 moved to their current residence in Laurel, Maryland on a property that used to be the Beltsville Speedway. In 1990 they began offering a Masters program.

Since the time that my wife bought me a small telescope in 1973 I bought a few small telescopes and then made a few larger ones along the way, and from many of the other projects that helped me to become an Astronomy and Science writer I decided to end my working career. For 42 years I was employed as a Flight Simulator Technician for the U.S. Air Force, a Simulator Field Engineer and Electronics Engineer for Link Aviation, a Flight Simulator Technician/Engineer for Eastern Airlines, an Electronics Technician and Radio Telescope Operator at the USNO in Miami, Florida and finally an Electronics Engineer/Senior Technician at the USNO in Washington, DC.

On May 18, 2001 the entire USNO Time Service and several USNO astronomers gave me a retirement lunch and presentations, including the model of the 26-inch dome and plaque. I officially retired on June 30, 2001 but took off using weeks of unused vacation time. What started me on this road in life was being at the right place at the right time. My retirement consisted of 8 years and 2 days USAF time and 12 years and 10 days of FERS time for 20 years and 12 days combined.

Time Service Retirement Plaque and Model of the 26-inch Dome Presented to me on May 18, 2001, retirement certificate and 20-Year Pin

[CURRICULUM VITAE]