New Mexico Society of Professional Engineers

50th Anniversary

Outstanding Engineering Achievement Award

The Very Large Array Radio Telescope

On the Plains of San Augustin near Datil, New Mexico

Submitted by The National Radio Astronomy Observatory

June 7, 1997
Albuquerque Country Club
Albuquerque, NM

NMSPE 50th Anniversary Engineering Achievement Award Entry Form

Submission Category: Research and Development.

Achievement or Project name and description:

The Very Large Array Radio Telescope erected on the Plains of San Augustin, near Datil, N. M.

The VLA Project consists of twenty-seven 25 meter diameter, 235 ton radio antennas designed to be movable over 40 miles of double railroad track laid in the form of an equiangular "Y", which through aperture synthesis, produces radio pictures equivalent to those which would require a single telescope with a diameter of 22 miles. Also included are very sophisticated electronics and computer systems, site buildings and utilities.

The VLA was the most powerful radio telescope in the world when it was finished in 1980 and after over sixteen years of full time operation remains the premier instrument of its type. It is the most productive radio telescope in the world with requests for observing time exceeding available hours by a factor of two, even though the instrument operates 24-hours per day, 362-days per year. In 1996 the VLA was used by 662 observers from 172 scientific institutions, from 25 nations of the world. It is rare that an issue of a major astronomical journal appears without reporting some results based on VLA observations.

The VLA is also one of the most precise instruments in the world. When in the extended array and used at a frequency of 43 GHz it gives a resolution of 0.04 arc seconds; sufficient to see a golf ball at a distance of 100 miles.

Date Completed: Dedication and full operation: October 10, 1980.

Name, address, and phone of engineering company:

General overall design and construction: Associated Universities Inc. The National Radio Astronomy Observatory, 520 Edgemont Road, Charlottesville, VA 22903-2475. Telephone (804) 296-0211. Local office P.O. Box 0, Socorro, NM 87801. Telephone (505) 835-7000.

Design of site facilities: BWH/CVR Joint Venture, of Albuquerque, NM.

Date submitted; April 5, 1997

Name and title of individual submitting entry:

John H. Lancaster, PE Program Manager, VLA Program and former Assistant Director, NRAO.

Signature 

Chapter (Location of Activity): Albuquerque, and Socorro, NM

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The Very Large Radio Telescope Page –2--

Describe achievements and innovations in engineering:

MECHANICAL DESIGN: Responsible person: William G. Horne, PE

Led the design of the massive 25-meter diameter, 235-ton antennas that achieved a reflector surface accuracy of 0.5 millimeters or 0.020 inches throughout all operating positions of the antenna; and completed their construction within the established budget and time frame.

Led the design of a transportation system involving two 90-ton 24-wheel transporters which lift the 235-ton antennas and transports them to any one of 72 antenna foundations on the three wye arms. A novel feature is that at the 90° turnouts to the antenna foundations the transporter lowers steadying jacks and then lifts and rotated its trucks 90° to make the turn. This saved a very sizable expenditure for switches and extra railroad trackage.

ELECTRONIC DESIGN: Responsible person: Sander Weinreb, Ph.D.

The electronic systems receive radio signals at various frequency bands between 300 and 50,000 MHz or at wavelengths from 90 to 0.7 cm. With a maximum sensitivity, with signal integration, of about 10 micro Janskys where one Jansky is 10 exp -26 per meter squared per Hertz. In order to lower excess signal noise, parts of the receivers are cooled to 18° Kelvin or minus 433° Fahrenheit. The signals are then sent through the first major 60 mm helix waveguide system to be built in the US, to the Control Building where they are correlated with signals from all other antennas in a massive digital correlator and then fed to the computers. The VLA can detect the very faint radio signals coming from astronomical objects at the very edge of the universe.

COMPUTER DESIGN: Responsible person: Barry Clark, Ph.D.

When early preliminary cost estimates from the large computer companies for the two major computer systems were in the tens of millions of dollars, NRAO decided to design the systems and the necessary software to control the antennas, acquire and process data, and also the system which the scientists would use to manipulate the data and turn it into useful maps. This work was completed at a cost of $6,400,000. And involved one of the first uses of mini-computers for a major task.

SITE DESIGN: Responsible person: Richard Vaughan, PE of the BWH/CVR Joint Venture.

The design consisted of approximately 40 miles of double railroad track, 75 antenna foundations and special 90° turnouts, a Control Building, Cafeteria Building, Shop Building, Service Buildings, three Guest Houses, all site utilities and site work. Special design was required for the 75 antenna foundations due to poor soil and the great need for precise stability. The array is so large that the curvature of the earth had to be factored into the foundation design, and the antenna foundations tilted so that all antennas were in parallel planes. Design of the Control Building involved complex requirements for the electronics and the computers; such as special electrical shielding to prevent computer noise from contaminating the received radio data.

SITE CONSTRUCTION: Responsible person: Forrest Wells, PE.

It was necessary to take many unusual steps to lower construction costs. Among these were:

a. Early estimates called for the procurement of 14,000 tons of rail at $90. per ton. Within months after the VLA was authorized the near-east oil embargo hit and the cost of rail zoomed to $250, and then to $300. per ton, which translated into a possible $2,000,000 budget overrun.

A major drive was undertaken to find surplus rail throughout the Country. Twenty-eight sites from coast to coast were salvaged. A total of 14,031 tons were recovered and shipped to the site at a delivered cost of $53.36 per ton.

b. Due to multi-year financing it was necessary to divide the railroad construction into six separate contracts. The first three went well but for the fourth the US Department of Labor issued a Davis-Bacon Wage Determination stating that the fourth and subsequent railroad contracts would have to be let using the much higher Building Trades wage rates. This would have increased the cost of the VLA by $2,500,000. This decision was appealed to the courts and after eighteen months was reversed.

c. The change order cost percentage for all site work to total bid cost was one half of one percent.

MANAGEMENT: Responsible person: John H. Lancaster, PE.

The cost of the VLA Program was limited to $78,578,000, within 4% of the estimated cost of $76,000,000 submitted to the National Science Foundation and the Congress in March 1971. During this period the various price indicators showed cost increases of 150 to 180%.

The VLA was completed nearly one year ahead of the schedule set out in 1972.

Number of employees on this project:

The maximum number of NRAO employees working on the VLA at one time during its nine year design and construction period was 133. However during this time 335 were hired. This does not include the several hundred people who were working at one time or another for the various fabrication and construction contractors..

Economic contribution and impact:

The immediate success of the VLA resulted in the authorization of the Very Long Baseline Array, a $86,500,000 program which stretches the telescope baseline from the State of Washington to Saint Croix in the Virgin Islands and from the State of New Hampshire to the State of Hawaii. Both this instrument and the VLA are operated and administered from Socorro, NM. Total present and continuing staff for these operation are 192 persons. In 1996 the yearly local payroll amounted to $7,800,000 and operating supplies, materials and utilities added another $ $1,000,000 to the New Mexico economy.

Construction expenditures for these two instruments within State amounted to approximately $55,000,000.

The construction of these two instruments brought New Mexico to the forefront of astronomy locations within the United States and greatly strengthened the Astronomy Departments at the University of New Mexico, New Mexico State University and New Mexico Tech.

The impact of the VLA on the tourist trade is substantial. The VLA site and its Information Center have become a tourist destination, with over 15,000 people visiting the VLA site each year.

Awards and Recognition:

The VLA has been highlighted in innumerable scientific and popular magazines and newspapers.

Several movies have had scenes take at the VLA site and the forthcoming movie based upon Carl Sagan's book "Contact", which will be released in July 1997, is based upon the VLA.

In July 1981 the VLA was named as "One of the Ten Outstanding Engineering Achievements in the United States" in the 15th Annual Competition of the National Society of Engineers.

NASA awarded the VLA Certificates of Appreciation in 1989 for receiving faint radio signals from Voyager as it passed Neptune and in 1995 for receiving signals from the Galileo probe as it plunged into Jupiter's atmosphere.

In a 1996 book entitled "Amazing Structures" by Michael Pollard and published by Barnes & Noble the VLA was highlighted along with the Great Pyramid, the Great Wall of China, the Statue of Liberty, Empire State Building, the Sydney Harbor Bridge and others outstanding structures.

A Brief History of the Very Large Array Radio Telescope:

In 1961, about 36 years ago, a group of NRAO scientists in Green Bank, WV began dreaming and planning for an instrument that would produce images equal to those produced by the world's greatest optical telescopes. In 1967 the first proposal was submitted to the National Science Foundation, but not until 1972, eleven years later did the Congress authorize and fund the program. The site on the Plains of San Augustin was selected by 1971 after a nation wide search, and approved by the National Academy of Science in 1972. The instrument was completed in 1980, nineteen years after the first dreams were expressed

Photographs of the VLA:

Photo 1. General aerial view of the Very Large Array Radio Telescope on the Plains of San Augustin, N.M. showing all 27 antennas in the "D" array configuration.

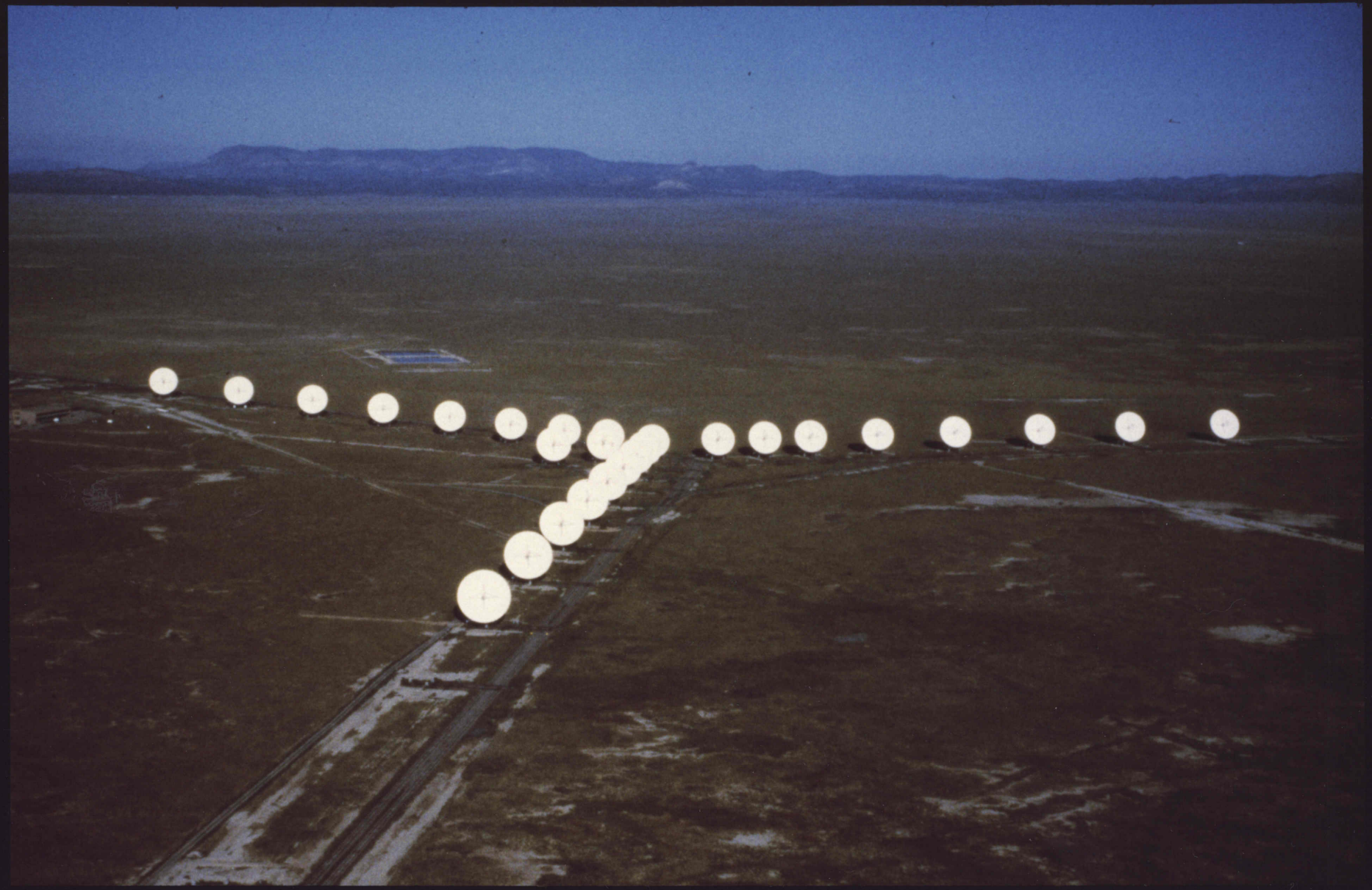
Photo 2. Ground view of the VLA antennas on the North arm of the wye.

Photo 3. Ground view of a 235-ton VLA antenna on its 90-ton transporter moving along the double track railway. Note the triangular base supporting the azimuth bearing, the alidade supporting the elevation bearings, and the very intricate framing for the reflector surface, which has an accuracy of 0.5 mm or .020 inches, rms. The movable reflector weighs in excess of 100-tons.

Photo 4. A 100-foot high VLA antenna and transporter crossing U.S. Route 60 on its way to a foundation on the north arm of the "A" array. This was the first antenna to cross Route U.S. 60 and aroused much media attention.

Photo 5. A lonely VLA antenna in winter snow some 13-miles from the center of the wye. Note the focusing asymmetrical sub-reflector which directs radio signals to any one of seven receivers.

The VLA was constructed and is operated by The National Radio Astronomy Observatory, a facility of The National Science Foundation under a Cooperative Agreement with Associated Universities, Inc.



VLA Photo No. 1. General aerial view of the Vary Large Array Radio Telescope on the Plains of San Augustin, N.M., showing all 27 antennas in the "D" array configuration.

VLA Photo No. 2. Ground view of the VLA antennas on the North arm of the wye.

VLA Photo No. 3. Ground view of a 235-ton antenna on its 80-ton transporter moving along the double track railway. The reflector has an accuracy of 0.5 mm or 0.020 inches, rms. The movable reflector weighs in excess of 100-tons.


STOP

VLA Photo No. 4. A 100-foot high VLA antenna and transporter crossing U.S. Route 60 on its way to a foundation on the north arm of the "A" array. This was the first antenna to cross Route U.S. 60 and arroused much media attention.

VLA Photo No. 5. A lonely VLA antenna in winter snow some 13-miles from the center of the wye. Note the focusing asymmetrical sub-reflector which directs the radio signals to any one of seven receivers.