Engineering a Telescope Array

How Many Astronomers and Engineers Does It Take to Build a Telescope Array? Part II

STEM careers video

Teacher & Learner Guide

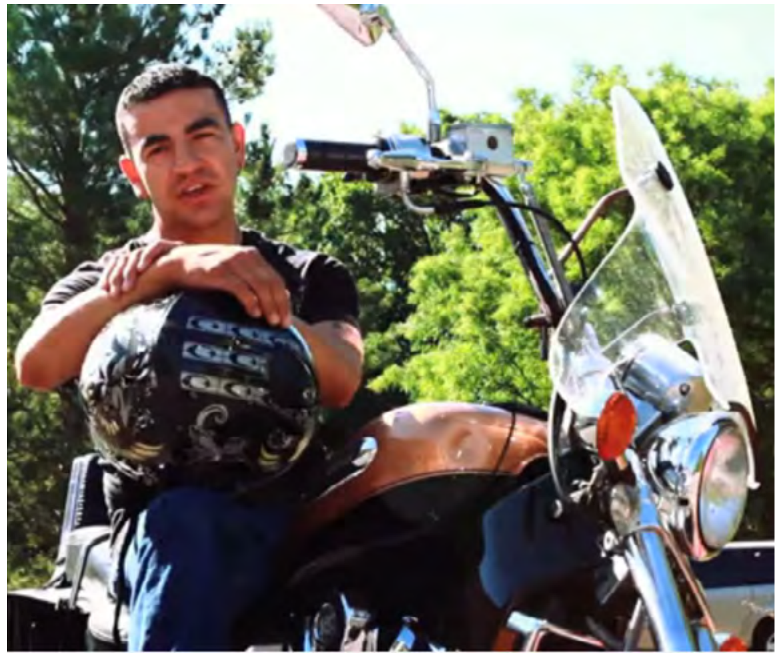
This guide provides background information about the setting and context of the short film, answers frequently asked questions, and suggests topics for student discussion or reflective writing.

Background information

The Very Large Array (VLA) is an astronomical observatory located on the Plains of San Agustin, near Socorro, New Mexico. The array is a Y-shaped arrangement of 27 radio telescopes, with reflectors (dishes) that are each 82 feet in diameter. The VLA allows scientists to look at the Sun, the planets, pulsars, black holes, and even distant quasars (galaxy cores). It detects hydrogen, the primary fuel for building new stars, and other elements scattered throughout our own Milky Way and other galaxies. The VLA can also be used to receive signals from spacecraft after they are launched.

Radio astronomy allows scientists to see what is happening in distant parts of our galaxy. This is important because it allows us to gather information about the composition of stars and other celestial bodies by detecting which elements are present in and around them. This helps us to understand the galaxy's past and the formation of stars and planets within it.

Scientists from all over the world use the information gathered by the VLA. Many people work at the VLA to keep everything running smoothly and to adjust the telescopes so that they are correctly positioned, programmed, and maintained. Data is collected 24 hours per day, every day of the year.



Frequently Asked Questions (FAQs)

How is a radio telescope different from an optical telescope?

When we hear the word *telescope* we usually think of an optical telescope, which greatly magnifies visible objects in the sky. A radio telescope, however, shows what is invisible, allowing us to "see" celestial objects emitting radiation at frequencies we can't detect with our eyes. Imagine driving a car in dense fog. Even with your headlights on, you aren't able to see very far in front of you. If your car could process and display radio waves, you'd be able to see through the fog! A radio telescope can similarly peer through dust and find shrouded objects in the sky. We are able to translate this information and use it to "see" distant planets, stars, galaxies, and other celestial bodies.

What is a telescope array?
A telescope array is a group of telescopes arranged so that, as a set, they function similarly to one giant telescope. This allows astronomers to gather higher quality information, generating high resolution data with great sensitivity to faint signals. One downside to having a number of small reflective surfaces (dishes) is that even though the collection of telescopes covers a large area, there are gaps in the information they can gather. If one antenna in the array breaks or malfunctions, the array will lose some sensitivity. If that particular antenna is programmed to a certain frequency, the quality of the data at that frequency would diminish. If we were able to have one giant dish covering the entire area of the VLA, it would be stronger and more capable of detecting faint signals.

What kind of information can an array gather?
Each telescope in an array can be programmed to observe the sky at specific wavelengths. In the case of the VLA, astronomers often focus on hydrogen gas (at a wavelength of 21 cm); therefore, the array focuses on the L band, which is about 20 cm in wavelength. Programming the telescope to work at this frequency helps us look at galaxies like the Milky Way, which contains a lot of hydrogen gas.

What are the different parts of the telescope?
A radio telescope is made up of a dish, or reflecting surface (the most visible part of the telescope), and antennas/receivers, which can be positioned to collect radio waves from different areas on the sky. The dish focuses radio waves onto antennas, which are sensitive to certain wavelengths. The antennas then send data to a correlator, one of the less obvious, but critical, components of the telescope array. A correlator is a dedicated computer that helps to transform raw data into an image or spectrum that can be used in scientific research. Other parts of the telescope include specialized computer hardware that traps the signals from the antennas and monitors local conditions, mechanical gearboxes that control the movements of the antennas, cryogenics to keep sensitive electronics cool, and fiberoptics to transmit data.

Other equipment that Eric mentions in the video includes electronics such as field programmable gate arrays (FPGAs) and the modules (specialized computer hardware that process the signals from the antennas). Eric also mentions the structural components of the telescope, such as gearboxes, the pedestal room, and the elevation landing.

What is cryogenics, and why is it important to radio telescopes?
Cryogenics is a branch of physics dealing with the effects of cold temperatures. In radio astronomy, heat produces noise that interferes with faint radio signals. Regions near the equator, which provides the best view of the skies, also tend to be warm. The effect of heat can be mitigated by placing the arrays at high elevations.

What is a correlator?
A correlator is a computer that is programmed to combine data from multiple telescopes into a single, unified signal.

Why is it important to observe outer space at many frequencies?
Knowing what is going on in outer space helps us to understand the history of our galaxy and the universe, how stars and planets formed, how the Earth formed, and whether other planets might have conditions capable of supporting life. Astronomers also study the mysteries of the cosmos out of pure curiosity. Discoveries with practical applications often arise from unrelated research: for example, spiral density wave theory, used to model traffic flows on freeways, emerged from astronomical research.

How is the telescope "aimed" at different things? What do you do to aim it at something new?
"Aiming" a telescope involves two things: one is selecting an antenna sensitive to the proper wavelengths. The other involves directionality, or physically aiming the telescope. The telescope is built on tracks so that it can be moved around (like a house on wheels) and placed in very precise positions. It also has mechanisms for adjusting the angular positioning of the dish—one is called the azimuth bearing and is a little bit like a hinge that spins the telescope around like a top.

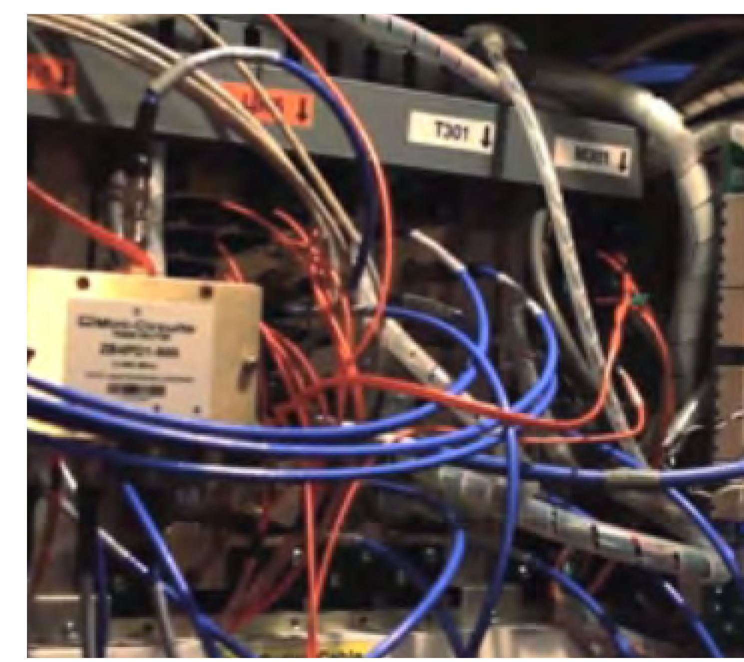
Questions for Class Discussion

Before watching:
1. When you think of astronomy, what do you imagine? What kinds of equipment do you think astronomers use?

2. When you picture people who work with giant telescopes, who comes to mind? Do you think these people went to college? What do you think they studied?

After watching:
1. What other jobs do you think people do at the VLA?

Notes for the discussion
Eric Chavez has one astronomy-related job that might not immediately come to mind when you think about people who work with giant telescopes. The information collected by the VLA is shared with scientists all over the world. The technology controlling the telescopes is used in telescopes across the world. How do you think data is shared with scientists in other locations? Who do you think manages the data? Who do you think designs the telescopes and all of the equipment needed to keep them working? In other videos in this series, you can learn about a data librarian and an engineer who work at the VLA. You can also meet a museum director who focuses on education and inspiring students at a giant radio telescope in Puerto Rico. All of these people work in astronomy.



2. What are your career goals? What do you think you need to do to achieve those goals? Are you surprised by the fact that Eric Chavez is able to work in the field of astronomy with a two-year degree?

Notes for the discussion
Eric Chavez mentions that he has an associate's degree in electronics engineering technology. This degree generally includes courses in math, electricity, basic electronics, and applied electronics. It also covers some basic engineering principles. We often think of science as a field requiring a doctorate (a PhD), but there are many ways to participate in scientific research. There are many less obvious jobs within scientific fields that require varying levels of education in combination with a strong work ethic and an interest in learning.

3. What traits does Eric Chavez have that make him good at his job?

Notes for the discussion
Eric mentions that he is very diligent, and he also seems comfortable with the physical tasks required for the job, such as working at great heights or in confined spaces. In many ways, these qualities are just as important as his technical knowledge.

4. Why do you think Eric's work is important? What would happen to the telescope if people like Eric weren't taking care of it? What would happen to the information scientists need?

Notes for the discussion
Remember that the VLA operates 24 hours per day and seven days per week, and all of the telescopes are needed in order to produce quality data.

5. **If we were to build a radio telescope on the Moon, which jobs do you think might be needed that were similar to those at VLA? What other jobs would need to be added in order to build and maintain the telescope? What about sending data back to Earth?**

Notes for the discussion
Many fields, particularly in the sciences, are constantly changing as we invent new technologies. Advances in

computing alone have made so many things possible that were impossible only a decade ago. In the future, careers in science may be very different from what they are today, but they will still rely upon the kinds of skills and methods of thinking gained while taking classes in the sciences. It's conceivable that we could place a radio telescope on the Moon in your lifetime. The Moon is cold, quiet, and isolated, and thus an ideal location for gathering information from distant parts of the galaxy and beyond.

For more information:

The Very Large Array website:
https://public.nrao.edu/telescopes/vla/

See how interferometry works:
https://public.nrao.edu/interferometry-explained/

Who works at the VLA?
https://www.vla.nrao.edu/genpub/work/

Questions for Reflection

These can be used as writing assignments, as homework, or as in-class assignments.

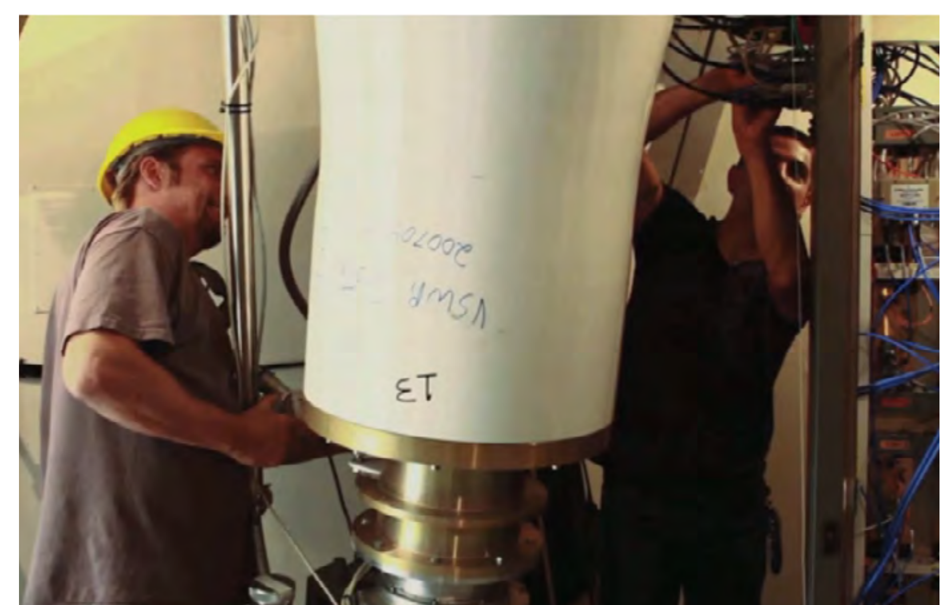
1. What do people in your family do for work? Did they have to complete a certain level of education to do their jobs? Do your parents encourage you to go far with your education? Do you talk with them about your educational and career goals?

2. What are your skills? Do you wish you could work in a certain field, but you aren't sure you could? Do some reading about a place where you'd like to work. Do they have a jobs page online? Look at the types of things the company or organization does. Even if a job isn't listed on the jobs page, it might exist. See if it is possible to volunteer at a place you find interesting.

3. This video and others in the series focus on people who went to college in New Mexico, and who now work in New Mexico in the field of astronomy. Do you see yourself staying near to your family or hometown? It isn't always necessary to go to school far away or move far away in order to have an interesting career. If staying close to where you are is important to you, try to locate companies or organizations nearby that do work in a field that interests you. The VLA might have surprised you because it's in the middle of a sparsely populated desert, but it's a facility that is important to scientists around the world.

4. When scientists are asked how they came to work where they did, or how they became interested in a certain field, they often cite childhood experiences or problems they wanted to solve when they were kids. What are some experiences that had a big impact on you? Have those experiences influenced what classes you took? Have any of those experiences involved a problem you wanted to solve?

5. Eric Chavez tells us a little bit about his background growing up in the projects and on welfare. How do you think his childhood influenced his decision to get an associate's degree and to work at the VLA? Eric says that he wants his kids to go farther than he has. Do you think Eric's parents told him something similar? What personal qualities does Eric have that make him good at a job that involves both attention to detail and learning new things?



For more information about our educational film series or to discuss its use in a educational setting, please contact the GEAS Project at New Mexico State University.

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