Radio Astronomy's Crumbling Showpiece

Years of deferred maintenance are turning the VLA into an emblem of astronomy's threatened infrastructure

ON THE PLAINS OF SAN AUGUSTIN, NEW Mexico—Not too many radio astronomers have ever felt the need to become railroad experts. But here at the Very Large Array (VLA), where 27 radio antennas are routinely shuttled around the arid grassland on some 65 kilometers of railroad track, deputy director Richard Sramek has had very little choice in the matter. Walking slowly between a pair of rails that runs straight toward the distant mountains, Sramek pauses at one of the wooden ties. Railroad ties are expected to crack some, he explains, but in this particular tie, the cracks have reached one of the big steel spikes that supposedly hold the rails in place. Sramek reaches down and pulls the spike out of the timber with his fingertips. It isn't holding anything in place.

"Fortunately," he says, "we haven't had any disasters—yet." But the fact is that the VLA's 190,000 ties are rotting out faster than the facility can afford to replace them. Moving the 25-meter-tall antennas over the crumbling rails has increasingly become a white-knuckle nightmare. It's all too easy to imagine one of the huge, fragile dishes slipping off the rails and crashing into a heap of twisted metal.

For the nation's radio astronomers, these rotting railroad ties—and less visible problems at the VLA like collapsing manholes, deteriorating power cables, failed bearings, inadequate computers, and aging instruments—are a major threat to research plans. When the $150-million facility was completed in 1980, it defined the state of the art in radio astronomy, combining the signals collected by the 27 antennas to produce radio images of quasars, galaxies, and planets that exceeded the clarity of optical images and were more than 100 times better than any radio images before it. Used by more than 600 astronomers per year, it remains the country's premier radio telescope.

But, what with mounting maintenance problems and outdated equipment, the VLA is gradually falling short of researchers' expectations. In the worst cases it actually breaks down, with its power cables shorted out or an antenna bearing frozen. But even when everything is working smoothly, researchers are painfully aware of the disparity between what the facility does now and what it could do with a few well-chosen upgrades.

Moreover, the VLA is but an extreme case of the decay in all the U.S. national observatories. Even at smaller facilities, the neglect resulting from chronic funding shortages is beginning to show up in the form of antiquated detectors, the slow attrition of key technical personnel, and the cancellation of new instrumentation programs, such as the adaptive-optics project at Kitt Peak National Observatory. This past March, when the National Academy of Science's "Bahcall Committee" published its survey of astronomy's needs for the 1990s (*Science*, 22 March, p. 1429), it pointedly concluded that the highest priority for ground-based astronomy was not some new piece of hardware, but "Restoring the Infrastructure"—repairing and modernizing existing equipment. By no coincidence, the committee's published report drives home that conclusion with a photograph of the VLA railroad ties.

The funding squeeze that brought the VLA to this pass began about 1985, recalls Paul Vanden Bout, director of the National Radio Astronomy Observatories (NRAO) in Charlottesville, Virginia, which runs the array and other radio telescopes across the country on behalf of the National Science Foundation (NSF). That was the year the NSF asked Congress for money to start construction of the $85-million Very Long Baseline Array (VLBA), a system of 10 radio telescopes spaced across all of North America and Hawaii that would produce images with at least 1000 times greater magnification than the VLA's. In effect, it would function as radio astronomy's telephoto lens, while the VLA would continue as the community's workhorse wide-angle lens.

Aging beauty. *Antennas along one arm of the Very Large Array.*

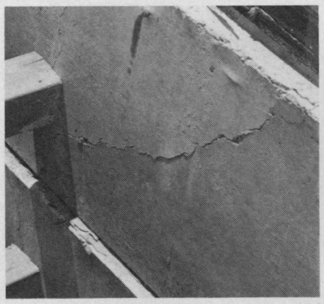
Peter Menzel

The new array was given the go-ahead. But congressional pressures to boost NSF funding for education led to a budget for ground-based astronomy that has not even kept pace with inflation—and that has had to absorb the entire VLBA cost to boot. Since 1984, says Vanden Bout, budgets for maintenance and operations at all the national observatories have declined about 20% in real terms, paralleling a similar decline in the grants to individual investigators.

The VLA was hit especially hard by the decline, says Vanden Bout, because it came just when the array began to pay the price for corners that had to be cut during its construction in the late 1970s. The most notable example is the rail system itself.

Laid out in a huge "Y" with 21-kilometer arms, the rails are used to move the antennas inward and outward. Such a shift is routinely carried out every few months, and it has an effect very much like that of a zoom lens: The wider the spacing of the antennas, the higher the array's magnification and the narrower its field of view. The antennas have to be carried one by one on a specially designed transporter, which picks up each antenna from its siding, balances it like a gargantuan champagne glass, and then slowly moves it down the rails to its new position. Together, the transporter and antenna weigh some 300 tons—25 tons on each of the transporter's 12 axles.

The problem, says Vanden Bout, is that every ounce of that weight is bearing down on rails that date back as far as 1902, and on ties that were hewn in the 1930s. To save on construction costs, the NSF built the railroad from materials salvaged from abandoned railroads. And the arid conditions of New Mexico are causing old ties from wet regions of the United States to deteriorate much faster than anyone expected. Every year, the VLA's four-man rail crew now replaces 1000 to 3000 of the most severely rotted ties, which is barely enough to keep pace with the progressive disintegration. To make any real headway against the problem, says Vanden Bout, they would have to boost that rate to at least 6000 ties per year. But that would cost an extra $265,000 per year that the VLA doesn't have.



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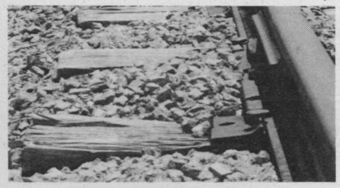

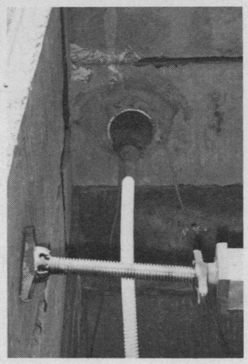

Signs of the times. *Crumbling concrete in some of the 100 manholes; several of the thousands of cracked railroad ties.*

Another cost-cutting measure gone bad is the series of manholes giving maintenance crews access to the VLA's buried waveguides—the delicate metal pipes that carry radio signals from the antennas back to the control room for processing. There are more than 100 of the manholes, one at each antenna siding. To save money, they were originally built by stacking up standard cemetery burial vaults whose bottoms had been removed. But alas, says Vanden Bout, the concrete of the vaults did not contain reinforcing bars. So now, after 10 years, the soil pressure is causing the manholes to buckle inward. At least a dozen are on the verge of collapse right now, threatening to crush the fragile waveguide. The worst are being replaced with a sturdier design on an emergency basis, says Vanden Bout. But all of them need to be replaced as soon as possible. Total cost: 100 times $3000.

Finally, says Vanden Bout, the VLA's maintenance woes have been compounded by bad luck. Along each arm of the array, for example, run three buried electrical cables supplying power to the antennas. At the time of construction, cables of this type were widely used by U.S. electric utility companies. However, as the utilities and the astronomers have since learned to their sorrow, the polyethylene insulation on the cables deteriorates at an increasing rate as it ages. Eventually there comes a voltage surge or a thunderstorm—the latter being a frequent event on the plains of San Augustin in summer—and the power catastrophically short-circuits into the ground.

"We now have a growing collection of burned-up power cables," sighs Sramek. Each short circuit announces itself as a sudden disappearance of data coming from one whole arm of the array. Since repairs can take anywhere from a couple of hours to a couple of days, and since visiting astronomers are typically awarded no more than 12 hours of observing time at a shot, this is disruptive, to say the least.

The only solution is to replace all the cables at a cost of some $1.35 million, says Vanden Bout. Happily, about 25% of that cost has already been borne by NASA, which replaced the cables in the inner regions of the arms when it borrowed the VLA as a receiver for the Voyager encounter with Neptune in August 1989. But that still leaves 75% of the recabling cost to be paid for by scarce NSF funds.

Add to that the bad luck of last spring. One night, as two technicians were driving past antenna 21, they heard loud grinding noises from its normally quiet drive mechanism. Today, while its 26 companions are scanning the sky in unison like a corps de ballet, antenna 21 sits forlornly staring at the zenith. Those grinding noises turned out to be coming from a bearing well on its way to self-destruction. To replace the bearing, technicians will have to design and build a $160,000 steel framework that will lift the antenna dish completely off its pedestal. Worse, says Sramek, "we don't know how pervasive the problem is"—whether the bearing failure is just a fluke, or the first of many.

With scarce funds needed just to keep the rails sound and the antennas turning, there's little to spare for another part of the infrastructure problem—the need to update equipment. The array's computers, for example, are fast being overwhelmed by the astronomers' ever-increasing demands for data processing. As a matter of routine, VLA images have to undergo extensive processing to clean up noise and ghost images produced by the array itself. Moreover, some projects, such as a search for very fast but very faint pulsars in a dense globular cluster, demand hours of specialized processing beyond that. The facility's current computers are simply too small and antiquated to keep up.

The upshot is that exciting observing proposals are routinely turned away because their computational demands are prohibitive, says Vanden Bout. He and his colleagues have been trying to address that shortfall since 1987, when they drew up an "Array Telescope Computing Plan." The plan proposed that the NSF initially spend $10 million for new hardware, plus an additional $1 million per year after that for new algorithm development, high-powered graphics workstations, high capacity data storage and archiving, and networks. But the money never materialized. Vanden Bout submitted a somewhat downscaled version of the proposal last year, and is keeping his fingers crossed.

Other well-targeted updates would also have big payoffs. Sramek points out that the VLA's sensitivity could be increased tenfold by modernizing the antennas' aging receivers, replacing the buried waveguides with modern fiber optic cables, and upgrading the electronics that combine the 27 signals into a single image. Doing so would cost $36 million over the next 10 years. But it would also allow the array to accommodate 10 times as many users, he says—or even better, to tackle projects that are currently out of the question. Mapping the surface composition of Pluto—a project that is regularly proposed and rejected because it would now take 50 hours of observing time—would become the work of an afternoon.

Taking care of this and all the other maintenance and infrastructure needs at the VLA and other national radio facilities would mean increasing the NRAO's $18-million annual budget by some $7.3 million, according to a 5-year plan that Vanden Bout prepared this past April in response to the Bahcall Committee report. That's a hefty increase in the current budgetary climate, he admits. But it's still less than 4% of what the VLA cost in the first place. "The VLA could be 10 times as powerful as it is now for a small fraction of the original investment," he says.

The question, as always, is whether such arguments, which are being made for optical astronomy as well, can be translated into real money. There are signs that Washington is at least listening. Astronomers say they have heard nothing but praise on Capitol Hill for the Bahcall report, with its emphasis on infrastructure. And at the NSF, astronomy chief Julie Lutz was able to include a 10% increase for infrastructure in its fiscal 1992 budget request, which was submitted to Congress in February. "If the NSF budget holds, that's what we're in for," she says.

Of course, that's a very big "if." Quite aside from the usual vagaries of congressional budget actions, last fall's budget agreement puts NSF funding into a zero-sum battle against housing and veterans' affairs—not to mention NASA's $30-billion space station.

Vanden Bout, for his part, takes a wait-and-see attitude. "Washington likes problems that build up to a crisis, and then they can fix it for good," he says. But a crisis is just what he and his colleagues want to avert. They'd like to see astronomical infrastructure get the same kind of steady funding that is needed to keep a bridge safe or a railroad running. At the VLA, he says, "we've learned the same thing the railroad people have: You have to keep after it *all* the time." ■ **M. MITCHELL WALDROP**