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The Origins and Early Years of NRAO

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Abstract. In this talk I give my recollections of the origins and early years of the NRAO.

1. Origins

I am going to start with a rough chronology of some of the events that led to the birth of the NRAO.

In 1953, Bart Bok and Donald Menzel at Harvard, Jerome Wiesner at MIT, and John Hagen at the Naval Research Laboratory (NRL) began informal discussions about the possibility of getting a large radio telescope for their mutual benefit.

In January 1954 a three-day conference on Radio Astronomy in Washington D.C. was the catalyst for several subsequent developments in US radio astronomy. After the conference the National Science Foundation (NSF) formed an advisory panel to advise it on how to stimulate the development of radio astronomy in the country. In May 1954, Menzel, on behalf of the Harvard/MIT/NRL group, wrote a letter to Associated Universities, Inc. (AUI) suggesting that AUI do a feasibility study for a national facility that would be open to all. In response to that letter, AUI held a conference at its New York offices, attended by astronomers from around the country, to see whether there was widespread support for the Menzel proposal. When it appeared that there was, AUI formed an advisory committee to help formulate a plan for the feasibility study.

Shortly after that meeting, Bob Dicke wrote a letter to the AUI advisory committee suggesting that they consider an interferometer array for the proposed observatory. The emphasis up to this point had been on a big dish. In his letter to AUI, Menzel had proposed that the principal instrument of the facility be a large parabola, 600 foot diameter or larger. The people who had started this were interested in the 21 cm line and in short-wavelength radio astronomy, and John Hagen—one of the few people in the world who was doing centimeter-wave work at the time—flatly stated that centimeter-wave interferometry would not work. In his letter, Dicke suggested that the committee consider a three-element interferometer: one fixed parabola and two movable ones on a circular track around the fixed one to give a number of close spacings. He included calculations to show that the array was about as good as a single dish of equivalent size. He was talking about aperture synthesis but he did not call it that. He was way

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ahead of his time. As far as I can remember, Dicke's letter was never discussed, and I did not know about it until a few weeks ago.

A proposal for a feasibility study was submitted to the NSF in July 1954. AUI received study funds in February 1955. Dick Emberson, a physicist who was assistant to the AUI president, would lead the study with the aid of the advisory committee, now renamed steering committee.

There were two big controversies related to the origins of the NRAO. The first one had to do with what the principal telescope should be. The original idea was for a 600 foot or larger dish. Thank goodness that got shot down. I don't know what would have happened to the NRAO if AUI had actually tried to build a 600 foot dish—it might not have survived. It got shot down first by Merle Tuve at the Department of Terrestrial Magnetism (DTM) who thought it was far too grandiose a scheme. Tuve was a member of the NSF advisory panel on Radio Astronomy. The NSF advisory panel and the AUI steering committee had several members in common but were often at odds about what should be done. In this case the NSF panel strongly endorsed Tuve's objections and the AUI steering committee dropped the idea of a 600 foot dish. The committee turned its attention instead to a 140 foot telescope that would work to 3 cm wavelength. That instrument had been proposed as an "off the shelf" telescope to fill in until the 600 foot was built. It originally was to have an alt-azimuth mount, and three or four preliminary designs were commissioned. None of the designs proved particularly appealing to the steering committee. It was finally decided that the mount would be equatorial, partly because of the difficulty that was being experienced with analog coordinate converters at the time (the NRL 50 foot reflector was on an old gun mount and had notoriously poor pointing characteristics) and partly because Tuve made a strong appeal for an equatorial mount. So the principal telescope of the proposed new observatory would be an equatorially mounted solid-surface paraboloid that would operate to 3 cm wavelength. AUI commissioned Ned Ashton (who had designed the NRL 50 foot dish) to design the 140 foot telescope.

In December 1955, the steering committee recommended Green Bank as the site. The NSF had decreed that the site be within 300 miles of Washington DC, and with that constraint Green Bank was an easy and relatively noncontroversial choice. A mild objection was raised by Merle Tuve, who wanted the site to be closer to Washington National Airport so that it would be more easily accessible to visiting observers.

AUI submitted a "Plan for a Radio Observatory" to the NSF in August 1956. It included a preliminary design and cost estimate for the 140 foot dish. There then were three months of acrimonious debate about who was going to run the new observatory—that was the second big controversy related to the formation of the NRAO.

The first controversy had pitted Merle Tuve, who was director of DTM, against Lloyd Berkner, the president of AUI, and others on the AUI steering committee. Fortunately, Tuve won that one and the principal instrument of the observatory would be a paraboloid of 140 foot diameter, not 600 foot.

The second controversy—about who was going to run the new observatory—also pitted Merle Tuve against Lloyd Berkner and AUI. At the symposium dinner the other night, Bernie Burke described the relationship between Tuve and Berkner. It was a significant factor throughout the events leading to the forma-

Figure 1. Alan Waterman and Lloyd Berkner at the contract signing in November of 1956. The other people in the picture that I can identify are Waterman's secretary LeeAnne Embry and Frank Callender, the man with the two-day growth of beard behind and between Waterman and Berkner. Callender at that time was working for the NSF, but Berkner hired him almost immediately to be the first business manager at the NRAO. Photo courtesy of the National Science Foundation.

tion of the NRAO . In the case of this second controversy, AUI won and wound up with the job of developing and running the NRAO.

While this controversy was going on, the first telescope was actually built in Green Bank in the summer of 1956. The West Virginia legislature had passed an act just a month or so earlier that would prohibit the generation of radio-frequency interference in the vicinity of Green Bank, but the act did not go into effect until there was actually observing going on at the site. So AUI decided to start some observing. A very simple interferometer consisting of two dipoles, a Hallicrafters receiver, and a strip-chart recorder was put together by Ed McLain and Ben Yaplee from NRL and was set up in the garden of what is now the Hannah House recreation area in September 1956. It monitored solar radio noise at 30 MHz, and we operated it for a number of years.

In November of 1956, Alan Waterman, Director of NSF, and Lloyd Berkner, President of AUI, signed the agreement that brought the NRAO into existence (Figure 1). The five-year contract called for site development, 140 foot construction and operations, but no other telescopes, and NSF told Congress the NRAO would not grow.

When the contract was signed Berkner became the acting director of the observatory, and four people were transferred from the AUI payroll to the NRAO payroll—Dick Emberson who had led the feasibility study and who was the Project Manager for the 140 foot, his secretary Mary Beth, an engineer, John Carroll, who was working on the 140 foot design, and me. Of the four of us, only I moved to Green Bank—in the summer of 1957. John Findlay and Frank Drake showed up very shortly thereafter.

At that time, Green Bank consisted of a post office, a small store, a garage, and a few houses. The village population, plus surroundings—the village and its suburbs—probably numbered fewer than a hundred people. Arbovale, which is up the road a couple of miles, was even smaller. The nearest bank or movie theater was thirty miles away in Marlinton. The nearest hospital was about fifty miles away in Elkins—a hard drive across the mountains—but the nearest liquor store was in Cass, just a couple of miles away. The telephone exchange was Cass XY: Cass 13 or Cass 24, or something like that. It was a party-line system, and to make a telephone call you picked the receiver off the wall and put it to your ear, then cranked a handle to get the operator and incidentally alert everybody else on the line so they could listen to what you had to say. The NRAO had one of the few single-party lines in the county, and I always thought that the observatory's phone number ought to be Cass A, but the phone company would not go along with that.

2. Some Green Bank Pioneers

Figure 2 shows photographs of twelve of the Green Bank pioneers, more or less in the order in which they arrived at Green Bank. Some of them only stayed for a few years, some stayed for many years. Some are still with the NRAO at other sites, and some are here in this room today. All of them were willing early in their careers to move to the wilds of West Virginia to this new observatory which had an uncertain future, and I think every one of them made unique contributions to the observatory and to astronomy.

3. How Do You Run A National Observatory Whose Mission Is Service To Visitors?

- What is the role of a scientific staff?
- How should observing time be allocated?
- What facilities and services should be provided?
- How much development of new telescopes and receivers should be done?

I think the answers to these questions go a long way to defining the character of the institution. Today, these questions have been answered in various ways by different national centers and the answers have evolved over time, but in the late fifties and early sixties there were no answers at all. The questions were controversial and they occupied a great deal of my time for the next five or ten years, at least. One extreme position, for example, was originally proposed by Merle Tuve: there should not be any scientific staff at the observatory, and only minimal facilities and services. Tuve wanted to build a receiver, and feed, himself and bring it down to Green Bank in a truck. Bernie Burke (Bernie was working at the Department of Terrestrial Magnetism at the time) would hook it up to the telescope; they would essentially camp out—I suppose in tents—and cook over an open fire, and that would be the observatory. That was an extreme position that fortunately was not held by many, but there were lots of variations

Figure 2. Green Bank pioneers. Left to right, top row: John Findlay, Frank Drake, Cam Wade, Hein Hvatum; second row: Sebastian von Hoerner, Frank Low, Dave Hogg, Sandy Weinreb; bottom row: Ken Kellermann, Barry Clark, Mort Roberts, Bill Howard. (Photos courtesy of the NRAO archives.)

of it. The wisdom and support of the AUI presidents and board members of that era, especially I. I. Rabi and G. F. Tape, were of enormous value, and gradually we worked out what we thought were the appropriate answers for NRAO.

4. The 140 Foot Telescope

The 140 foot telescope was selected by the steering committee to be the centerpiece of the observatory, and its design was begun by AUI during the feasibility study. In 1958 AUI issued a Request For Proposals for a fixed-price contract to build this telescope. Eight bids were received, ranging in price from two million to twelve million dollars. This wide range should have raised a red flag, but it didn't, and AUI went ahead and let a contract to the E.W.Bliss company for $4.75 million to build the telescope by the end of 1960. In the event, the telescope cost $14 million and was not completed until 1965. I think it is the

largest equatorially mounted telescope that was ever built. It is the only construction project that was ever managed by AUI directly rather than through Brookhaven National Laboratory or the NRAO, and I think it highlighted the dangers of management and design by committee. I am not going to go into the interesting problems that caused the delay and cost overrun, but I do want to describe some of the consequences of the problems. Problems developed shortly after the Bliss contract was signed, and it soon became apparent that the 140 foot completion would be severely delayed. Because it was supposed to be the main instrument of the NRAO, its delay had a big impact on a lot of other things that went on at the observatory from that point on. First of all, Lloyd Berkner, president, and Dick Emberson, 140 foot project manager, both resigned from AUI. Some months later Otto Struve, director of the NRAO, also resigned.

When Struve became director, he had agreed with Berkner that the design and construction of the 140 foot would continue to be under the control of AUI, which had started it before Struve arrived, and that AUI would finish the telescope, then turn it over to Struve and the NRAO to operate. When things began to go bad with the project, Struve regretted that decision and tried to get it rescinded, but he failed. After Berkner and Emberson resigned, the Board drastically restructured the project. Ted Reynolds, a Board member and vice president of Harvard, was put in charge, Bliss was fired, Ashton was fired, and Stone & Webster Engineering Co. was engaged to do extensive redesign and manage the project. But Struve did not get the authority over the project that he wanted, and this is probably one of the reasons why he resigned. In a letter to Isidor Rabi, who became the president of AUI for a time after Berkner's resignation, Struve complained that numerous non-scientific meetings with individuals and groups were causing him a lot of fatigue and preventing him from doing the science he wanted to do. All of those meetings had to be about the problems of the 140 foot, over which he had little influence.

Another consequence of the 140 foot delay was the 300 foot telescope. Faced with what looked like an indefinite delay in what was supposed to be the principal instrument of the observatory, we felt that the NRAO needed something soon that would be attractive to visiting observers so it could start to function as the national center it was meant to be. So the 300 foot was conceived and built in a very short time.

The 140 foot problems, and especially the cost overrun, for a time threatened the continued existence of the NRAO. Some astronomers, including some members of NRAO's visiting committee, began to question out loud whether the NRAO was worth the money NSF was pouring into it, and I remember at least one meeting of AUI, NRAO, and NSF representatives with the Bureau of the Budget (BOB), now called Office of Management and Budget (OMB), to discuss issues raised by the 140 foot overrun and delay.

A lot of lessons were learned in the course of the 140 foot problems, and some were applied to later projects including the 36 foot and the Very Large Array (VLA).

In spite of all this, the 140 foot turned out to be a pretty good telescope. In fact it was a very good telescope, and it did great work for 35 years or so. In retrospect I think it was well worth the $14 million that it wound up costing.

5. The 300 Foot Telescope

We—meaning Drake, Findlay, Wade, and I—knew that if we were going to have any chance of getting some sort of forefront telescope that would attract visitors, in the face of the problems of the 140 foot and the money that was being spent on them, it was going to have to be cheap, quick, and have characteristics that would make it attractive to observers. So it was chosen to be a 300 foot aperture that would work at 21 cm. That made it the largest 21 cm dish in the world at the time; and even though, to keep the price low and the acquisition time short, it was a transit instrument, it would still be a powerful, unique instrument for radio astronomy

It was first proposed in 1958, but the NSF turned it down cold. Those young guys at Green Bank didn't know what they were talking about, and the NSF was not about to put any more money into something just on their say-so. Then Struve arrived in 1959 and he endorsed the 300 foot very strongly. Immediately the NSF flip-flopped—it was a great telescope and it got into the budget. John Findlay became the project manager for the telescope, and it was designed and constructed in a four year period for a cost of about $800,000. There was one time interval there that still boggles my mind. Struve wrote to the NSF for approval of the construction contract. He sent the letter by ordinary mail and got a reply back four days later, with approval! So not only did the US Postal Service make a round-trip delivery between Green Bank and Washington in four days, but the NSF actually approved the thing within a day or so of receiving the letter. It's just remarkable, and I bet that kind of speed has not been duplicated since, not by the NSF and not by the US Postal Service.

Figure 3 is a picture of Struve at the ground-breaking of the 300 foot telescope.

The 300 foot was completed in 1962, and with it I think the NRAO truly did become a national center with a world-class telescope for use by visitors, and visitors came. We were able to start trying to answer some of the questions about how to behave as a national center. So it accomplished what we hoped it would. Because of that, and because of the exciting science that came from it, it has always been my favorite telescope in Green Bank.

6. Otto Struve

Otto Struve was the first resident director in Green Bank. He came in July of 1959 and he resigned in November of 1961. He had a short tenure but a long impact.

As I have already mentioned, he obtained approval for the 300 foot, a key step with long-reaching effect on the observatory. He also obtained money for a library. That may not sound like much, especially today as people don't seem to use libraries much anymore—they just use their computers—but he was an astronomer of the old school and he thought that an observatory ought to have a really good library. The original budget for the observatory did not contain anything like enough money for a decent library, so Struve talked the NSF into more money, and as a result the NRAO has an excellent library, including the

Figure 3. Struve at the ground-breaking for the 300 foot telescope. The fellow with his arm in the air is Bernie Burke. The person behind Struve is George Swenson, and the other person with his back to the camera is Ed Faelten, who did the detailed design work for the 300 foot. (Photo courtesy of the NRAO archives.)

major journals all the way back to their beginnings. If one was in Green Bank valley in the sixties, before computers, a good library was important.

He helped to get the 140 foot construction back on track, not quite the way he wished, but all of his fussing was a big help in getting it going again.

He hosted, in 1961, a US-USSR radio-astronomy conference. This was supposed to become an annual event, but it was the only one ever held. I think Frank Drake was both the local organizing committee and the scientific organizing committee. It was a a lot of fun. In the picture (Figure 4), Struve has a great big smile on his face, and I think it is largely because this was the first time he had any real contact with Russian and Soviet astronomers since he had left Russia in about 1918 or 1919. He really enjoyed this conference.

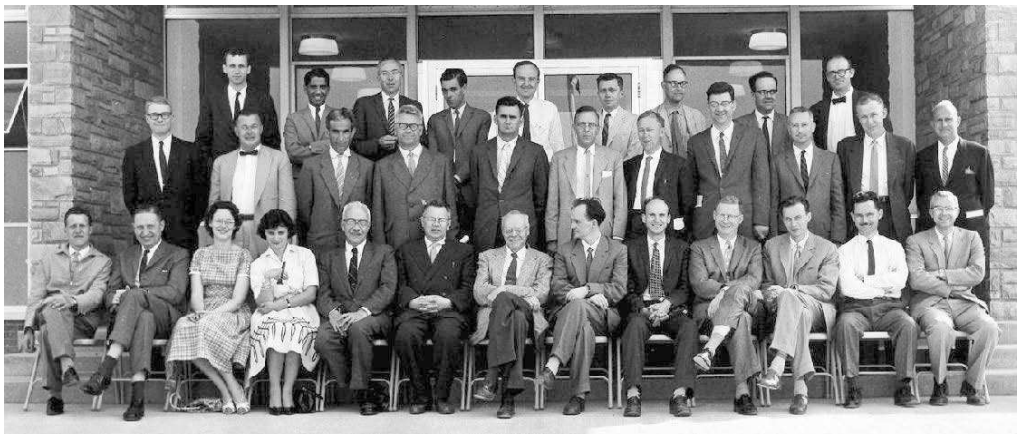

Figure 4. Participants in the 1961 US–USSR Radio Astronomy Conference. Left to right, front row: Getmantsev, Haddock, M. J. Wade, Edmundsen (interpreter), Minkowski, Vitkevitch, Struve, Sorochenko, Firor, Keller, Kuzmin, Bracewell, Drake. Middle row: C. Wade, McClain, Sanamyan, Kalachev, Stanley, Barrett, Weaver, Swenson, Mayer, Heeschen, Kraus. Back row: Field, Menon, Seeger, Woltjer, Sandage, Lilley, Blaauw, Kahn, Burke. (Photo courtesy of the NRAO archives.)

Struve resigned in November of 1961 for the reasons I have already mentioned. He was a fine person and a great astronomer, and he made important contributions to NRAO. I have always felt sad that his final years were made so stressful by the problems with the 140 foot telescope.

That ended the first five years of NRAO, almost to the day.

Almost simultaneously with the announcement of Struve's resignation, AUI announced the appointment of Joe Pawsey to be the next director. He was going to come in about a year, and AUI asked me to be the acting director in the interim, to hold the fort for them. Pawsey was a well-known Australian radio astronomer, and we at Green Bank were happy with that selection. We were looking forward to his coming, but unfortunately he contracted brain cancer and was unable to take the job.

7. The Second Five Years

The second five years were busy and interesting. The 300 foot was completed in 1962, the 140 foot finally was finished in 1965, the 85 foot interferometer was built as a test bed for the VLA, and the 36 foot was built on Kitt Peak. And all of those instruments were in use by observers from around the world.

The 36 foot was the result of the initiative of Frank Drake and Frank Low. Somewhere around 1959 or 1960, Drake bought a bolometer from Frank Low, who at that time was at Texas Instruments, and he also bought a 5 foot dish. He set up the dish on the roof of a little hut out in a field and began to do millimeter astronomy in Green Bank. Equally importantly, he talked Frank

Figure 5. An early AUI dinner in Arbovale. (Photo courtesy of the NRAO archives.)

Low into coming to Green Bank. They both left the NRAO before the 36 foot was actually built, but between them they were responsible for getting it going.

The VLA and VLBI were also started during this period, and in 1965 NRAO's headquarters were moved to Charlottesville.

That is a very rough description of the first years at Green Bank, but I have one final slide—of an early AUI NRAO banquet (Figure 5). You may recognize Cam Wade and his wife and Sebastian von Hoerner and maybe a couple of others. It was held in the Community Center in Arbovale in what looks sort of like a boxcar. The principal differences as I remember between that dinner and the one we had the other night were that that early one was free—and there weren't any speeches.

Discussion

Van der Laan: In those early days during the troubles with the 140 foot, did you have any interaction with Jodrell Bank or with the Dutch astronomers who were already running telescopes?

Heeschen: I don't recall any interaction with either of them. Husband, who had designed the Jodrell Bank telescope 250 foot telescope, was involved in early design work during the feasibility study. I don't recall Hooghoudt being involved anywhere.

Ransom: I've always been told that the headquarters was moved to Charlottesville because of complaining wives at Green Bank. How true is that?

Heeschen: Not true at all. At least, if it is true, the complaints came through their husbands. The move to Charlottesville was initiated by the electronics group, if I remember rightly. Hein Hvatum and Sandy Weinreb began to complain that they couldn't get people to stay and they wanted to move to Charlottesville and that sort of grew. It was apparent at that time that we were going to have a site at Kitt Peak and also that we were going to have a site somewhere for the VLA, so it just made sense for all of these reasons to move to Charlottesville.

Lewis: I also understood that part of NRAO's foundation was in connection with the Sputniks having gone up, and you haven't mentioned those.

Heeschen: Sputnik had a lot to do with the funding of astronomy in the United States. It stimulated a whole lot of stuff, but I don't think it had anything specific to do with Green Bank, no more so than it did with other developments in radio astronomy in the States.

Condon: I would point out to the SKA community that the cost of constructing the 300 foot telescope was $130 million per square kilometer.

Heeschen: And it only worked to 20 cm at that time.