From: CVAX::ABRIDLE 5-DEC-1988 12:39
To: @REPLACE,ABRIDLE
Subj: My reaction to Dec 2/3 meeting

Here are some observations and conclusions based on what I heard at the Dec 2/3 meeting at Green Bank.

A. Array vs Single Dish

The advantages of an array are:

1. Can provide large total aperture without the structural design innovation needed for equivalent monolithic antenna. This dominates choice if the required total aperture much exceeds equivalent of 100-m diameter.

2. Reduces pointing problems, wind loads for given final resolution.

3. Small elements might use conventional offset-feed geometries to minimize aperture blockage and get very clean primary beam.

4. Can place some control of beam shape in hands of observer.

Tradeoffs are about even on:

1. Speed, and complexity of electronics, for large-area surveys (if the single dish uses array feeds for such work).

2. Initial construction cost (at about 100-m effective aperture); dish needs more structure, array needs electronics and computing. Much above 100-m aperture, array should win easily because dish requires pioneering design.

3. Self-calibration of atmosphere. Dish must have array feeds and a large correlator; array has what it needs anyway. Techniques are better developed for arrays, but principles are well understood for dish also.

4. Both can provide high surface brightness sensitivity and zero spacing data if all auto and cross correlations are used in the array.

The advantages of a single dish are:

1. Can keep electromagnetic path very clean by dismounting all unwanted receivers and feeds whenever it is important to have low sidelobes, little stray radiation and RFI, flat spectral baselines. Array elements get cluttered in practice because there is operational pressure to leave equipment for all wavelengths in place on all elements all the time.

2. Can make better use of state-of-the-art receivers, i.e. can run with prototypes and/or devote all maintenance resources to keeping a small number of packages in tip-top shape. Faster response to innovative receiver design is possible.

3. Re-engineering of feeds and receivers is much cheaper because there are fewer of them.

4. Can be maintained and operated by less people, as there are fewer item to be maintained and attended to.

B. RFI performance

Green Bank's "trump card" as a site is the Quiet Zone, and much of the exciting low-frequency science (high-redshift HI, multifrequency pulsar work, etc.) requires exemplary RFI rejection capabilities. We should plan eventually to do whatever we can toward interference excision by signal processing. But we must get off to the best possible start by emphasizing RFI performance and primary beam cleanliness in the design of the antenna(s). The RFI environment will only get worse with time, so we must invest as much as possible now in design that will reduce far-out sidelobes.

The enormous generic advantage of interferometers for RFI rejection is based on fringe rate and delay discrimination. These advantages vanish asymptotically for compact arrays, though some use can still be made of them in practical finite arrays if the RFI is impulsive.

The worst RFI signals are from satellites, against which very clean beams are needed as the first line of defence. An array of small elements could use offset-feed technology to maximize clear aperture and so minimize RFI acceptance through far-out sidelobes. But an extremely compact array might negate this for much low elevation work because of aperture blockage and scattering off adjacent dishes. RFI rejection would be best for a not-too-compact array of offset-feed dishes working near the zenith, or at azimuths and elevations for which blockage had been specially optimized (e.g. as one might do for the Galactic Center).

It will be difficult to use offset-feed technology for apertures of order 100m, except by illuminating off-axis sub-apertures from an on-axis minimum-blockage feed support (as was proposed for galactic HI work with the 300-ft before its demise). A new single dish should minimize use of massive feed supports, and perhaps maximize use of non-conducting guy wires with dielectric constants as close to unity as possible (are there any suitable strong materials ?) The single-tower geometry used on the Jodrell bank MkI, and the two-leg+guys geometry used on the 300-ft are preferable to a tripod or tetrapod, and modern versions of these should be considered.

A compact array would keep all the feeds closer to the ground than would a conventional dish with the same total aperture. This protects against local sources of interference getting directly to the feed, which may be an important problem at the lowest frequencies. The main RFI disadvantages of a compact array are dish-to-dish blockage, scattering and cross-talk. Most practical compact arrays (e.g. VLA D-array) have severe cross-talk problems, but none was aggressively designed to reduce this. We should be sure that we know how to eliminate self-interference before committing to a compact array.

C. Designs we should elimate now

The scientific goals presented at Green Bank ask for large apertures at low frequencies, but significant residual aperture at 3mm. I think we should therefore eliminate the following options:

1. A single 70-m class antenna going to 3mm. This will be too small to do exciting science at the low frequencies for which the Quiet Zone is an ideal location.

2. A large-aperture array of many cheap dishes operating only to 5 GHz, e.g. off-the-shelf cm-wave communications antennas. This will be cheap to construct but relatively expensive to operate, and will not service the high frequency applications.

3. A single 100-m class antenna with a conventional off-axis feed geometry. The feed tower will be prohibitively tall if the path lengths from to the dish are equalized enough that the dish can be illuminated satisfactorily by a broad-band feed with a reasonably symmetric beam. We should however remain open (for a while) to suggestions for clever geometries that would reduce the tower height without exacerbating the illumination problem.

D. What's left ?

Two possibilities occur to me:

1. An inner-panel, outer-mesh dish giving 100-to-130-m aperture at low frequencies and about 70-m aperture to as high a frequency as we can afford. We should shoot for useful performance at 3mm, but back off to 1 cm if this cannot be done at reasonable cost. The dish should have an on-axis but minimum-blockage design; we should plan to support optional slightly off-axis feeds to illuminate a fully clear sub-aperture for work that requires the ultimate in sidelobe suppression.

2. An array with one (central) element that operates up to 3mm and a surrounding ring of about 6 equal-sized elements that operate only up to about 5 GHz. The outer elements might be off-the-shelf communications antennas, and would not be used for the highest frequencies. The ring might be made reconfigurable to meet the blockage and resolution requirements of different experiments. The element size should probably be about 40-m. Possibly we could use an offset feed clear-aperture design at this diameter.

I suspect that the array would be more scientifically flexible for a given construction cost, but that it would cost more to operate, and to keep equipped with state-of-the-art receivers, in the long run. If it was provided with a "generous" computer capacity at the outset, the computer might also contribute significantly to the VLA/VLBA computing problem, and thus give Green Bank an extra role as an array computing center.

I marginally favor (1) because it would be cheaper to operate as a state of the art instrument, and so might be a better "matched filter" to the likely budget. But array options deserve a further hearing in-house, at least for a few more weeks.

From: CVAX::KKELLERM 6-DEC-1988 15:22
To: ABRIDLE,JLOCKMAN
Subj:

Memo to: P. Vanden Bout, G. Seielstad
From: K. Kellermann
Subject: Antenna Costs

The following estimates of the costs of large steerable antennas have become available since my Nov 28 memo (number in parenthesis is wavelength limit):

1) 100 meter (2cm) Lee King has scaled the VLBA design to estimate the cost and performance of a 100 meter antenna. Adding the cost of the subreflector, foundation, and contingency I come up with 59 M. This design is limited by gravitational deformations. Operation at 2 cm requires moving the subreflector to keep it a the optimum position. A further improvement in performance can be achieved by using the order of 60 motors to adjust the surface. This could be cheaper than introducing an homologous design.

2) 100 meter (1.3 cm): Scaling the cost of the above design by f-0.7 (JPL empirical law) suggests a cost of 80 M for a 1.3 cm antenna.

3) 300-ft (6 cm): RSI has estimated the cost of replacing the 300-ft as 6.74 M plus an additional 2.9 M to make it steerable in azimuth. Allowing for contingency would bring this to a total of 11.6 M. Note that this structure still has a 30 degree elevation limit. Considering this constraint, the RSI estimate is roughly consistent with the cost of an all-sky 6 cm 300-ft instrument estimated by the Fisher method of 15.8 M.

4) 450-ft (6 cm): Scaling the 300-ft dish by a 2.7 exponential law increases the cost to 35 M for the limited elevation instrument and 47 M for the full sky instrument.

5) 100 m (3 cm): JPL has a cost estimate from Ford Aerospace of 91 M. This is much higher than the numbers we have been considering, but can probably explained by the DSN requirements on slew speed, operating under high wind conditions and other gold plating that distinguishes JPL antennas from radio astronomy antennas.

6) 100 m (1.3 cm): MAN in New York has given an estimate of 38 M for reproducing the Effelsberg telescope in the United States as a joint effort between MAN and an American company. Note that this is about 10 M less than the estimate received about a year ago via MPIfR. I had incorrectly assigned this earlier estimate to Krupp/MAN whereas in fact it cam from Krupp (Germany) only.

Summary:

We can probably build a copy of the 100 meter Bonn dish for 40M to 50 M, or for the same price a fully steerable 140 meter telescope good to 6 cm. For 50 M to 60 M we can make it a little better than the Bonn dish, or a little bigger; but probably not both. For reference the following dish efficiencies (referred to

100 m aperture) have been measured at Bonn (Altenhoff and Wink 1988).

Wavelength	Efficiency
6 cm	47%
2 cm	36%
1.2 cm	21%
0.7 cm	16%
3.5 mm	5%

From: CVAX::ABRIDLE 7-DEC-1988 11:56
To: RBRAUN,ABRIDLE
Subj: INflation

The official NSF adjustment factor from 1982 to 1989 is x1.2589

The average cost of the VLBA antennas without subreflector is about $2.3M averaging over the 10 in the actual contract.

You gotta be real careful with price comparisons to note what is actually included as an "antenna". For most practical purposes you want "erected antenna+drives and servos+foundation". Subreflectors, control systems and electronics are usually costed separately because they often come from different manufacturers.

From: CVAX::ABRIDLE 7-DEC-1988 12:35
To: KKELLERM,ABRIDLE
Subj: TIW 32-m in 1982

I have dug into my files from the CLBA project, and exhumed the following information about the TIW 32-m antennas.

In 1982, they quoted to the CLBA project as follows:

32-m antenna type "A" - standard issue

45" peak pointing error
60% efficiency at 10 GHz
33% 20
26% 24

Antenna $1.7M Can i.e. $1.5M US
Drive 0.16M Can
Foundation 0.17M Can
Erect/test 0.46M Can

Total 2.5M Can i.e. $2.2M US

32-m antenna type "B" - an enhanced proposal, not then built anywhere

30" pointing error
40% efficiency at 24 GHz
"useful to 30 GHz"

Total 3.0M Can i.e. $2.7M US

The quotes were actually made to us by TIW Canada in Canadian dollars, and I have converted to US at the 0.9 rate that was operative back then. In fact, the head office of the people who made the quote was in California, so there was likely a "master" US price at that time and the erection/testing might well have been costed differently in the (warmer) US market.

If you convert to 1989 at the NSF rate, you'd have $2.8M for the Type A.

The Type B may be a figment of their imagination, given that they once asked the CLBA group to fund the upgrade design.

Note that at the same time, E-Systems estimated $3.2M Can for a 32-m scale-up of the VLA antenna, including erection, foundation and drive.

From: EXOS%"nraogba!rfisher@nrao1.CV.NRAO.EDU" 12-DEC-1988 09:49
To: ABRIDLE
Subj:

Return-path: <nraogba!rfisher@nrao1.CV.NRAO.EDU>
Received: from nrao1 (nrao1.CV.NRAO.EDU) by cvax
id 00001B9F002 ; Mon, 12 Dec 88 09:49:29 EST
Return-Path: <nraogba!rfisher@nrao1.CV.NRAO.EDU>
Received: by nrao1.CV.NRAO.EDU (4.12/DLB-1.4)
id AA03134; Mon, 12 Dec 88 09:55:37 est
Date: Mon, 12 Dec 88 09:55:37 est
Message-Id: <8812121455.AA03134@nrao1.CV.NRAO.EDU>
To: nrao1!abridle, nrao1!jlockman
To: nrao1!abridle, nrao1!jlockman

Here are some cross polarization numbers and beam dispacements as functions of full reflector subtended angle as seen from the feed for an offset reflector where the feed axis is at right angles to the reflector beam axis. The beam offset is the displacement between two oppositely circularly polarized beams. The linear cross polarization is peak relative to main beam. The total cross-polarization power is probably somewhat higher because there are two cross-polarized beams, one on each side of the main beam. These numbers are from graphs in Chu and Turrin, IEEE Trans. Antennas & Propagatation, Vol. AP-21, pp. 339-345, 1973.

Subtended Reflector Angle	Linear Cross Polarization	Circular Pol'n Beam Offset
28 deg.	-22.3 dB	0.166 HBPW
40	-19.1	0.240
60	-15.5	0.382
90	-11.8	0.626

A 28-degree subtended angle would reguire a longish feed whose aperture is between 4 and 8 wavelengths in diameter, depending on its bandwidth (wider bandwidth means bigger feed).

From: CVAX::ABRIDLE 12-DEC-1988 17:10
To: JLOCKMAN,ABRIDLE
Subj: The design

I talked with Paul about his reaction to alternative (i.e. off-axis) designs in the context of what will be done next. He will strike some sort of internal engineering review group to answer questions about tradeoffs in design parameters, and is willing to have them spend some effort on evaluating the radical design. But he points out that the driver will likely be NSF's reaction to all of this next week. If they are going to resist construction of *any* telescope, there will be more time for us to review options. But if they also jump on the "fast track", there may be only a week or so more to make the case.

On the practical side, I talked with Dick Thompson about possibilities for reducing the height of the tower. Obviously you can throw away some coverage around the zenith and bring the focus down toward the ground if you are also prepared to have the azimuth and "altitude" axes intersect not quite at right angles. But Dick also thinks you might be able to get to the zenith by taking a slightly different segment out of the master paraboloid.

I think the real issues it will boil down to will be (1) the cost of the big track, (2) the loss of aperture in the direction to the source that comes from the oblique projection and (3) whether there is a feasible driveygeometry for the reflector. Also, how far over the cliff of certainty Paul is prepared to hang - I'm not sure it's very far and I'm also not sure I blame him!

The key thing will be to make sure that some of the right questions are given to the engineering group when it is formed.

From: CVAX::ABRIDLE 13-DEC-1988 09:13
To: SBAUM,ABRIDLE
Subj: GB

The "how" is getting clearer, but the "why" will take a bit longer.
Right now we are in panic mode, as Senator Byrd has decreed that the telescope is to be replaced, and wants an outline plan for this by 5 Jan.
NSF is unhappy with this, but Byrd proposes to add the money to their budget so it is very likely to happen anyway. Right now most of the effort around here is going into specifying a new big dish, e.g. a 400-ft.

From: CVAX::LDADDARI "Larry D'Addario" 14-DEC-1988 14:29
To: ABRIDLE
Subj: memo about technical study group

From: CVAX::LDADDARI "Larry D'Addario" 13-DEC-1988 11:40
To: @TEAM,LDADDARI
Subj: Technical Study Group - New GB Telescope

13 December 1988

Memo to: Addressee
From: Larry D'Addario
Subject: The New Green Bank Telescope - technical study group

Paul Vanden Bout has requested that I convene a study group to investigate the major technical issues surrounding the new Green Bank telescope. You are invited to be part of this team.

We are asked to work quickly, with a report due on January 16. I have said that it is not possible to promise that all questions will be settled by then, but we should provide the best answers that can be obtained in that time. At the very least, we should be able to quantify some of the tradeoffs and specify how much work will be required to resolve the questions that remain.

As I see it, the boundary conditions are as follows:

(1) The telescope must be a single dish. Although my personal opinion is that the technical/scientific case for this decision is far from conclusive, it seems to be necessary politically. Our most objective reason for it is the minimization of operating costs.

(2) The aperture must be at least 100 m equivalent diameter. All of the important science proposed for the new instrument at the recent Green Bank workshop requires a collecting area of this order, and some (especially pulsars) would like much more. This may not be a hard boundary, but construction of a smaller instrument would require strong scientific justification, and even then may not be acceptable politically.

Within these constraints, we have the following major questions to consider:

A. What is the most cost-effective upper frequency limit? Should be apply such tricks as using only a portion of the aperture at high frequencies?

B. What is the most cost-effective size? Should we stop at 101 m or push for something much bigger?

C. Are some "unconventional" designs practical? How much can be gained in performance (sidelobes, interference rejection)? How much is sacrificed (polarization, cost, development time)?

I hope that most of you will be able to devote a large fraction of your time to this study over the next few weeks. If that is not possible for you, please let me know. Suggestions for other members of the team are also welcome. After mid-January, I expect that we will re-assess our situation; more work will no doubt be required, and it will probably be at a lower level for some of us and a higher level for others.

Let's get together in a teleconference on Thursday (Dec 15) to plan this work and to assign specific tasks to individuals. I suggest 11:00 EST; let me know today if that time is inconvenient. Between now and then, please send me your comments and suggestions via e-mail.

Addressees:
- Mike Balister
- Tim Cornwell
- Rick Fisher
- Lee King
- James Lamb
- Peter Napier
- John Payne
- S. Shrikanth
- Dick Thompson

Copies to:
- Bob Brown
- Darrell Emerson
- Ken Kellermann
- George Seielstad
- Paul Vanden Bout

From: CVAX::LDADDARI "Larry D'Ad2ario" 22-DEC-1988 14:39
To: @TEAM,LDADDARI
Subj: VLD - revised list of questions

VLD -- Questions for Technical Study Group
88/12/22

1. Specifications
   a. Absolute minima
      100m size
      5GHz upper frequency limit
   b. Desired
      very low sidelobes...but how low?
      very good interference rejection
      very good spectroscopic baselines
      higher upper frequency limit: 23 GHz, 43 GHz, 115 GHz.
   c. Miscellaneous
      polarization (?)
      lower frequency limit
      frequency agility vs. performance

2. Axially symmetric antenna
   a. What is the best we can do to minimize blockage?
   b. What is the size/frequency-limit tradeoff?
   c. What steps other than minimizing blockage can be used to mitigate sidelobes (for H I), interference, and standing waves?
   d. Prime focus vs. cassegrain: best crossover frequency?

3. Asymmetric antenna
   a. What is the largest feasible completely unblocked aperture? Is homology feasible?
   b. What sidelobe level and distribution is achievable with an unblocked design?
   c. What are the polarization properties?
   d. What is the best f/D?

4. Generic
   a. Pointing correction methods (real-time laser measurements of structure, etc.)
   b. Focal plane array provisions - how does this constrain the design?
   c. Active surface correction - open- and closed-loop methods
* d. Graded surface accuracy: should central portion be made to work to higher frequencies than the rest?

5. Radical ideas to be seriously considered
* a. Twin dish concept - e.g. 2x70m instead of 1x100m

*new since last version

From: CVAX::LDADDARI "Larry D'Addario" 23-DEC-1988 08:48
To: @TSG1,@TSG2
Subj: Reflections in on-axis antennas VLDTSG#3

From: CVAX::ATHOMPSO "Dick Thompson" 19-DEC-1988 09:32
To: LDADDARI, PNAPIER, JLOCKMAN, KKELLERM,ATHOMPSO
Subj: Reflection Problem in On-Axis Antennas.

Some ways of reducing or eliminating baseline problems resulting from reflections into a prime-focus feed are listed below. As I understand it, this problem is one of the major arguments for an off-axis antenna.

(1) Reflecting cone at vertex. Effective but produces far-out sidelobes.

(2) Patch of absorbing material at vertex. Produces a small increase in antenna temperature.
Area of patch need not be more than about 1% of
reflector area, so increase in antenna temperature is less than 3K.
Has this scheme been tried in practice?

(3) My suggestion: replace absorbing patch in (2) with antenna of similar aperture pionting up at feed. This could be a horn or small paraboloid. Terminate in load at 15K. The problem is to keep the small antenna well enough matched that very little of the incident power is reflected.
There should be no degradation on antenna temp. Has this ever been tried?

From: CVAX::LDADDARI "Larry D'Addario" 23-DEC-1988 08:52
To: @TSG1,@TSG2
Subj: TSG#4 Frequency Flexibility

From: CVAX::RNORROD 22-DEC-1988 15:05
To: @TEAM.DIS, LDADDARI
Subj: Frequency Flexibility

The following question was raised at the first team meeting: Should instantaneous frequency flexibility drive the antenna design? My feeling is that, while desirable and a worthy goal, it should not be a driving specification. Rapid receiver selection was necessary on the VLBA, but a major advantage of single dishes are the ability to mount special-purpose, optimized receivers and feeds. If we preclude the possibility of removing a subreflector to mount a 7-feed receiver, or a cryogenic 500-1000MHz receiver, or some as-yet-undreamed-of-receiver, we will have taken a giant step backward.

Sensitivity must be one of the driving specs for the new antenna. That means, at least in part, minimize antenna temperature and maximize effective aperture. We should look hard at any design decision that affects these adversely.

From: CVAX::LDADDARI "Larry D'Addario" 23-DEC-1988 08:55
To: @TSG1,@TSG2
Subj: TSG#5 Driving specs, R. Fisher

From: EXOS%"nraogba!rfisher@nrao1" 22-DEC-1988 21:24
To: LDADDARI
Subj: Driving specs

I very much agree that ultimate performance in a few key parameters (G/T, low scattering, etc.) should be the driving force in the design of the new antenna. Frequency flexibility and other such requirements should be secondary and at least temporarily sacrificed if necessary. We can play the trade-offs of performance and flexibility later, but let us not preclude the best sensitivity in the telescope's "native" mode. If we need to, we can get clever in producing flexibility as we learn, but I'd hate to have to use all of our cleverness to overcome built-in compromises. We should make sure that this telescope is the BEST at something significant and not just more of the same at a lot of things.

Rick

From: CVAX::LDADDARI "Larry D'Addario" 23-DEC-1988 09:42
To: @TSG1,@TSG2
Subj: TSG#6 Servoing a large surface/D.Wells

From: EXOS%"dwells@NRAO.EDU" 15-DEC-1988 16:40
To: LDADDARI
Subj: Servoing a Large Surface

To: L.D'Addario
Fm: D.Wells
Re: Active Servoing of a Large Surface
Cc: G.Seielstad, A.Farris

For a centimeter-wave antenna active servoing is not really necessary (numerous working antennas and design studies show this). But I strongly suspect that servoing is not very difficult for a centimeter-wave antenna, and maybe it is even trivial with today's technology. I further suspect that NRAO could make a cost savings with it by servoing a simpler, cheaper structure or else, even more scientifically important, that it would be able to build a much larger servoed antenna with the available money while maintaining the required surface accuracy.

I suggest that retro-reflectors be mounted on the structure, and that they be scanned by a laser ranging instrument, probably using computer-controlled galvanometer mirrors to point the laser beam at the reflectors. If the laser can achieve range accuracy in the neighborhood of 0.1mm, then we are home free. Two or three such instruments mounted around the prime focus feed or Cassegrain secondary, several meters apart, would yield simple triangulation to the retro-reflectors. One then solves for differential corrections to the actuators and applies them iteratively until the retro-reflectors are at the desired locations.

What are the desired locations of the reflectors in order that the panels form the best approximation to the ideal surface? One could use a theodolite to measure panel and reflector relative positions. My guess is that it would be better to calibrate the surface using holography with a satellite transmitter. In any case one could deduce differential corrections to the retro-reflector positions, which then imply application of differential corrections to the actuators. Once calibrated (periodically, and at multiple elevations if possible), the servo based on the laser ranging system can hold the configuration of the reflectors, and the panels must follow if they are sufficiently rigidly coupled to the reflectors. One might have to calibrate panel differential corrections as functions of temperatureoand elevation, of course.

Coupling the ranging system rigidly to the feeds would assure that the feeds would be 'on-axis'. Assuring that the beam points to the desired place on the sky is a separate issue. I suggest that retro-reflectors be mounted on piers in the ground around the telescope and that they also be ranged. Again, this only gives relative orientation servoing; it must be calibrated. Again, a theodolite will do, but looking at a source on the sky is even better, and probably easier. The overall result would be accurate pointing of a well-shaped beam, with automatic correction for the mechanical errors of the tracks, bearings and structure, plus automatic correction for the structure deformations due to temperature and average wind loading.

Suppose that the actuators are DC motors driving screws. Suppose that we put two simple photo-detectors near each associated retro-reflector, separated by more than a laser beamwidth, and wired so that one causes its motor to go clockwise and the other counterclockwise. This would enable us to activate any motor by simply pointing the laser at the appropriate photodetector, and the actuator displacement could be checked immediately by re-ranging on the associated retro-reflector. This would eliminate any need for encoding devices in the actuators and, even more important, it would eliminate all control wiring to the actuators, needing only DC power distribution.

Probably the laser ranging system should be an IR laser to cut through GB fog. I think that the computer power requirements for this sort of concept are not an issue.

Questions: (1) Are laser ranging instruments capable of 0.1mm precision (0.5mm might be good enough)? How rapidly can they give such a reading for practical beam power levels? (2) Can hundreds (thousands?) of electro-mechanical actuators be manufactured to be sufficiently reliable in a hostile outdoor environment? (3) Are there advantages to designing a homologously deforming surface and then servoing it? (4) Does active servoing either favor or discriminate against either conventional or unconventional (e.g., Lockman) designs?

From: CVAX::LDADDARI "Larry D'Addario" 5-JAN-1989 13:23
To: @TSG1,@TSG2,LDADDARI
Subj: Straw-man designs

890104 LRD.

In order to focus our studies more precisely, I suggest that we develop two straw-man designs in some detail:

(1) A symmetrical dish of 100m diameter with minimum blockage; and
(2) An unblocked dish of 80m diameter.

The unblocked dish would have greater effective area than Effelsberg if it has an aperture efficiency of 75%, and it might be as high as 80%. The symmetrical dish would have still greater effective area, but (presumably) higher sidelobes. The idea of the different sizes is to keep the costs somewhere near the same.

In both cases, the surface should be lambda/16 at 23 GHz and the pointing should be very good at 23 GHz. We should defer the question of higher frequency operation on the assumption that some level of higher frequency performance will be possible, to be determined later.

We should make some design choices in each case and carefully analyze the resulting performance. For example, we should specify the subreflector size and other optics details, setting the lowest frequency for Cassegrainian operation. We should then calculate the aperture efficiency and beam efficiency as a function of frequency, and estimate the far sidelobe level achieved. We should invent a scheme for maintaining accurate pointing. We should decide to what extent we'll make use of real-time adjustment of the surface. Finally, we should make some estimates of the costs.

Let's discuss this at our next meeting.

From: CVAX::PJACKSON "Phyllis Jackson" 23-MAR-1989 16:23
To: @SSTAFF.DIS,PJACKSON
Subj: Memo from PVB - New Green Bank Telescope

NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

M March 23, 1989

M E M O R A N D U M

To: Scientific Staff

From: P. A. Vanden Bout

Subject: New Green Bank Telescope

On the surface, the status of the new Green Bank telescope appears to be unresolved. Senators Byrd and Rockefeller have stated in a press release their strong preference for the telescope rather than the gravity wave detector. The public posture of the NSF is to maintain the scientific importance of both projects, with a preference for the gravity wave detector. If there is any action, it must be behind the scenes. The total absence of communication from both the NSF and senators offices leads me to believe there is a great deal of quiet action and that we would be wise to continue our efforts to refine the concept of the new telescope.

The largest remaining area of uncertainty is the cost-benefit tradeoff of an unblocked aperture. Qualitative arguments have been made, but these are insufficient for an informed decision. The arguments pro and con need to be tightened with numbers. We need funding to fully answer this question. Meanwhile, we should continue to discuss and study the elements of the problem we can address with time stolen from other duties.

Many other areas need attention, too. Most important are pointing and sureface control. The other areas of receivers, backends, control, and data analysis are important but less immediately urgent. Thoughts on all of these topics are welcome. I would like the interested parties to keep the memo series alive. Send contributions to K. Kellermann for possible inclusion in the series.

I would like to have the raw material in hand for a proposal or project book should we receive an urgent request from the Foundation.

PVB/j

From: CVAX::GATEWAY::"AIPS@UNMB" 24-APR-1989 13:24
To: ABRIDLE AT NRAO
Subj: Civil Engineers

Date sent: Mon, 24 Apr 89 11:15 MDT
To: ABRIDLE@NRAO
Original_To: Jnet%NRAO::ABRIDLE

Alan:

I wanted to again thank-you for the excellent talk last Thursday. Everyone thoroughly enjoyed it. The two engineers are Prof. Walter Gerstle and graduate student Ferhat Akgul. Ferhat will be finishing his Master's thesis on lunar radio telescope designs by the end of the summer.

How was the train ride back to CV?

Cheers,

Jack

From: CVAX::PJACKSON "Phyllis Jackson" 25-APR-1989 09:55
To: @SSTAFF.DIS,PJACKSON
Subj: Memo from P. Vanden Bout - re New Green Bank Telescope Proposal

NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

April 25, 1989

MEMORANDUM

To: Scientific Staff

From: P. A. Vanden Bout

Subj: Proposal for the New Green Bank Telescope

Informal discussions at NSF have led me to conclude that we should be prepared to submit a proposal for the new Green Bank Telescope on short notice. Accordingly, I have asked George Seielstad to organize this effort. The goal is to have a proposal in final form by the end of June. If one is necessary sooner than that, we will do our best to hurry the effort along.

To make the proposal definite, it will be written for a conventional design as the baseline plan. However, there will be a section describing the advantages and disadvantages of an unblocked design, and we will prepare to do enough work on an unblocked design to demonstrate that either the conventional design is the correct device or that we must change the baseline plan to an unblocked design. That is, the design of choice is conventional until our research demonstrates otherwise.

George has recruited the following people as team leaders for various sections of the proposal:

Science	Jim Condon
The Antenna	Larry D'Addario
Telescope Monitor and Control	Darrel Emerson and Rich Lacasse
Electronics	Roger Norrod
Site	Dave Hogg
Data Processing	Harvey Liszt
Operations	Jay Lockman

Their first meeting will be in Green Bank on April 25. Please communicate your ideas and thoughts in these areas to them soon.

PVB/j

From: CVAX::KKELLERM 10-MAY-1989 15:10
To: @STAFF.DIS
Subj: S. Von Hoerner visit

Sebastian Von Hoerner will be visiting Green Bank on May 20 and 21, and will be in CV on May 22-24 where he will be available for discussions about the with Sebastian. Talk with Lee if you want to participate.

On Wednesday, May 24, Gavril Grueff and Gianni Tofani will be in CV to join the discussions and to inform us of the plans and progress toward the construction of a large steerable telescope in Italy. I do not know many details but believe it is in the 50 meter class and will be located in Sardinia.

From: CVAX::LDADDARI "Larry D'Addario" 15-MAY-1989 08:55
To: @TSG1,@TSG2,LDADDARI
Subj: VLD basic parameters

As you probably know, we are now writing a formal proposal to the NSF for construction of a new large telescope in GB. The baseline instrument is to be a symmetrical dish, with continued study of the unblocked option.

But almost all other basic parameters are still open, and we now need to tie them down. In particular, it seems to me that much of the design falls out once we have set these two numbers:

- focal ratio
- subreflector size

These values were chosen rather arbitrarily for the TSG report, but now must be more carefully considered. The purpose of this message is to solicit your advice on what the considerations are.

For the focal ratio, it seems clear that 0.25 would be very small and 0.50 would be very large. As far as I know, all considerations favor a *small* focal ratio except one: prime focus feeds are inefficient at small f/D. Are there any other reasons for large f/D?

The subreflector size is a compromise between blockage and size of secondary feeds, among other considerations. The feeds can be made smaller by moving them closer to the subreflector in a feed cone, but then space for receivers and other feeds is reduced. What is the largest practical feed if we locate it at the vertex of the main reflector?

I have my own lists of considerations favoring large/small f/D and large/small subreflector size. But I would appreciate seeing your lists, in case I've missed something.

From: CVAX::LDADDARI "Larry D'Addario" 19-MAY-1989 15:18
To: @TSG1,@TSG2,LDADDARI
Subj: VLD discussion with SvH on 5/22-23

Sebastian von Hoerner will be in Charlottesville Monday and Tuesday May 22-23 for discussions about the new telescope. We will begin our meetings with him at 09:00 on Monday at the Edgemont Rd conference room; interested persons are invited to attend.

From: CVAX::LDADDARI "Larry D'Addario" 23-MAY-1989 14:32
To: @TSG1,@TSG2,LDADDARI
Subj: Proposed VLD optics; comments invited.

PROPOSED OPTICS FOR SYMMETRICAL ANTENNA

L. D'Addario, 890523

Basic dimensions:

Main reflector diameter, paraboloid	D	100 m
Focal length (primary)	F	30 m
Subreflector diameter, hyperboloid	d	10 m
Secondary focus height above vertex	h	5 m

Derived dimensions:

Focus to subreflector distance	L	22.26 m
Feed cone top max diameter		8.33 m
Effective focal length at secondary	F_e	241 m
Prime focus half angle		79.61 deg
Secondary focus half angle		11.73 deg
Sec. feed aperture for -14dB taper*	d_f	7.58 wavelengths

*Based on narrow-band (10%) feed, center wavelength; derived by scaling VLBA design.

Possible feeds:

A. Secondary focus -
92 cm band: feed aperture 6.97 m diameter
50 cm band: feed aperture 3.79 m diameter
Remarks- both of these apertures fit within the available feed cone, but are too big to allow other feeds to be mounted simultaneously. If constructed from conventional corrugated horns, they would be very big; the 50cm feed might be barely feasible to build (length about 11m) but installation and removal would be difficult. However, it may be possible to implement both of these feeds as planar arrays of small radiators; this should be investigated.
20 cm band: feed aperture 1.48 m diameter
Feeds for this and all shorter wavelengths can be installed on a rotating turret which fits entirely within the feed cone.

B. Prime focus -
Definitely required for wavelengths longer than 100 cm. May be required for 50 cm if light-weight secondary focus feed cannot be developed.

Performance:

Illum.eff. Spillover Product

Secondary focus	0.80?	0.92?	0.74?
Prime focus	0.65?	0.95?	0.62?

[NOTE!!! The above numbers are just guesses -- need to find the correct values to put in here. Can anyone help?]

Note: Allowing an additional 0.92 for blockage and 0.95 for miscellaneous, we get a prime focus aperture efficiency of 0.54? or an effective area of 4,256? m^2. This compares with about 3,500 m^2 for the 300 ft telescope at 320 MHz.

Options:

Lenses - for the shorter wavelengths, improved illumination efficiency from the secondary focus may be possible by including a dielectric lens as part of the feed.

Tertiary mirror - some receivers could be mounted in the space below the vertex of the main reflector by placing a tertiary mirror there. It would have to be an ellipsoid to achieve refocusing; the geometrical beam diameter is 2.08 m at a point 5 m below the vertex, so the tertiary would need to be several meters across, even for the shortest wavelengths.

From: EXOS%"nraogba!rnorrod@nrao1" 24-MAY-1989 13:09
To: ABRIDLE
Subj: Re: Proposed Optics

Return-path: <nraogba!rnorrod@nrao1>
Received: from nrao1 (nrao1.CV.NRAO.EDU) by cvax.CV.NRAO.EDU
id 000028AB002 ; Wed, 24 May 89 13:08:54 EDT
Return-Path: <nraogba!rnorrod@nrao1.CV.NRAO.EDU>
Received: by nrao1.CV.NRAO.EDU (4.12/DLB-1.5)
id AA29872; Wed, 24 May 89 13:12:44 edt
Date: Wed, 24 May 89 13:12:44 edt
Message-Id: <8905241712.AA29872@nrao1.CV.NRAO.EDU>
To: nrao1!abridle, nrao1!athompso, nrao1!athompson, nrao1!demerson,
nrao1!gseielstad, nrao1!jlamb, nrao1!jlockman, nrao1!jpayne,
nrao1!kkellermann, nrao1!ldaddari, nrao1!lking, nrao1!mbalister,
nrao1!pnapier, nrao1!pvandenbout, nrao1!rbrown, nrao1!ssrikant,
nrao1!tcornwel, rfisher, wbatrla
To: nrao1!abridle, nrao1!athompso, nrao1!athompson, nrao1!demerson,
nrao1!gseielstad, nrao1!jlamb, nrao1!jlockman, nrao1!jpayne,
nrao1!kkellermann, nrao1!ldaddari, nrao1!lking, nrao1!mbalister,
nrao1!pnapier, nrao1!pvandenbout, nrao1!rbrown, nrao1!ssrikant,
nrao1!tcornwel, rfisher, rnorrod, wbatrla

I think that 10% bandwidth feeds at the secondary focus are unacceptable because of the nearly continuous frequency coverage demanded by spectroscopy and the broad frequency range we need to cover. 50% bandwidth would be a better goal.

Feed size depends both on bandwidth and illumination angle required. It's dangerous to scale directly from VLBA sizes.

Roger Norrod

From: EXOS%"nraogba!rfisher@nrao1" 25-MAY-1989 10:29
To: ABRIDLE
Subj:

Return-path: <nraogba!rfisher@nrao1>
Received: from nrao1 (nrao1.CV.NRAO.EDU) by cvax.CV.NRAO.EDU
id 00001184002 ; Thu, 25 May 89 10:05:50 EDT
Return-Path: <nraogba!rfisher@nrao1.CV.NRAO.EDU>
Received: by nrao1.CV.NRAO.EDU (4.12/DLB-1.5)
id AA13376; Thu, 25 May 89 10:09:41 edt
Date: Thu, 25 May 89 10:09:41 edt
Message-Id: <8905251409.AA13376@nrao1.CV.NRAO.EDU>
To: nrao1!abridle, nrao1!dhogg, nrao1!gseielst, nrao1!hliszt, nrao1!jcondon,
nrao1!jlockman, nrao1!rlacasse, wbatrla
To: nrao1!abridle, nrao1!dhogg, nrao1!gseielst, nrao1!hliszt, nrao1!jcondon,
nrao1!jlockman, nrao1!rlacasse, wbatrla

Here are a few comments on recent memos in the technical design committee mail.

I agree with Larry's comment that the long wavelength secondary feeds are too big to be practical. From our experience at Green Bank and my feeling for the desires of the HI observers, I strongly suspect that 21-cm work will favor prime focus unless it is precluded by the secondary focus compromises. I can't emphasize enough how important 10 and 15% gains in G/T are to HI observers. I am really keen to see focal-plane array feeds developed, but it will be a long time before these match our current waveguide feed G/T's.

Also, because of feed size, I would guess that Jim Condon's multi-beam 6-cm survey receiver(s) will best be built at prime focus. Sorry to keep pushing prime focus so hard, but I would feel badly if our achievements of better G/T systems are designed out of the telescope. Remember that we are not shaping the dish, so we are not getting the efficiency gains of the VLBA design at the secondary focus either.

I see the rationale for a short F/D, but something as small as 0.30 is EXTREMELY uncomfortable for prime focus. Such a compromise would go against the fact that the pulsar and HI observers are the ones who want maximum G/T and multi-beam capability which will require efficient prime focus operation.

Sri touched on the problem when he mentioned that the hybrid mode feeds are near their cutoff size with an F/D of 0.43 and smaller F/D's will mean less efficiency. I agree with this from experience in designing the 2HE feeds.

May I recommend that you look at the article by Minnett and Thomas in Proc. IEE, Vol. 115, pp 1419-1430, 1968, reprinted in Love's book "Reflector Antennas" p 56. Figures 13 and 14 are particularly important. In this paper they calculate paraboloid focal plane fields and the theoretical maximum efficiencies obtainable with ideal hybrid mode feeds.

One conclusion to be drawn from this paper is that focal plane fields of small F/D paraboloids are fundamentally very difficult to match with waveguide feeds. In fact, for F/D's less than about 0.4 the power flow in part of the focal plane is reversed, and the area over which a given fraction of the power is spread increases with decreasing F/D. From figure 13 we can see that recovering the efficiency loss due to small F/D with bigger feeds is practically very difficult. A rough estimate from that diagram says that for the same size feed the efficiency at F/D=0.30 is about 83% of that at F/D=0.43. This is equivalent to an 8% reduction in aperture diameter.

Figure 14 shows that the feed aperture size for a given illumination efficiency is a minimum at F/D of about 0.6. The minimum is quite broad for low efficiency feeds but rather sharp for higher efficiency prime focus feeds. This is important when considering arrays of feeds for mult-ibeaming - higher F/D and smaller feeds allow closer beam spacing up to F/D=0.6 or so.

Another consideration for multi-beam work is that the field of view for a given off-axis-feed aperture efficiency increases with increasing F/D. Mapping and source searches are an important part of long-centimeter-wave work, and increasing the number of simultaneous beams is an extremely cost effective way of increasing the efficiency of a filled aperture telescope for this work.

Roger's comment about secondary feed bandwidth is quite right. We know how to make these feeds up to 1:2 bandwidth, and we know how to make 30-40% bandwidth OMT's so we might as well do it.

In your efficiency calculations, don't forget that we have never achieved the theoretical values. Discrepancies can be quite large. For example, for our single mode feeds we calculate about 65% efficiency and get about 52%. These differences seem typical. Compare only theoretical to theoretical values or measured to measured, and be very careful about cross comparisons. An efficiency of 54% seems very optimistic with an F/D of 0.3. What does Bonn get for aperture efficiency and spillover temperature at 21 cm?

I disagree with some of the technical points of Bernie Burke's letter and much of the conservatism. The offset reflector feed is not a new development project. Our current designs will work quite nicely with slightly different detailed parameters for all but the high polarization purity case. The F/D of 0.4 is no longer magic. My guess is that it came from the prime focus feed designs of some time ago which no longer apply. Bernie mentions an f-ratio of 0.2. I guess this is the F/D of the paraboliod from which the offset reflector is cut, but that is not terribly important from the feed design point of view. The subtended angle of the actual reflector is the main criterion.

At the December meeting I expressed reservations about the mechanical problems of the offset design and proposed that we look into low-blockage symmetrical ideas. So far we have not heard much in the way of encouragement about reducing symmetrical antenna blockage by more than 30-50%, which is much less than I had hoped.

Everyone must put their own weight on various parameters in the compromises. I realize that the symmetrical design is not the last word, but it is a good focus for comments.

So far, at least, I don't see a strong improvement on the Bonn antenna emerging. The blockage is somewhat better, and the high frequency surface may be bigger, but I don't see much more, yet. The baseline problem will be just as bad on the proposed design, and that is a very severe limitation to the Bonn antenna. The millimeter wave antennas are the only ones that have made significant improvements in this area, and they have done it because of large secondary focal ratios (path length modulators). We will be roundly criticized if we don't attack this problem in the basic design.

Interference immunity must be a strong consideration in the design. The Quiet Zone is an important element, but, if we don't improve on other telescopes in the ability to observe in the presence of satellites, the Quiet Zone advantage will be severely eroded over the lifetime of the antenna. Backends can be improved in this respect, but blockage must be aggressively reduced in this design if we are to improve on competing antennas. I've heard some valid reservations about how much scattering can be reduced, even with an offset design, but we may be forgetting that if we reduce the scattered power to about 0.5% of the feed response (about 10 dB below current designs) we can use absorber to achieve at least 10 dB additional reductions without substantial system noise penalty. Given this, a 20 dB reduction with the offset design sounds conservative.

At the risk of advocating something I don't really favor, I would make the point that, if we insist on secondary focus operation down to 50 cm, we should strongly shape the main reflector and go for maximum gain. We cannot use the potential wide field of view at secondary focus, anyway, because of size restrictions at all but the shortest wavelengths. My only point here is that we should make a big gain in AT LEAST one important parameter even if we can't say that it has a larger diameter than Bonn.

Rick Fisher
May 24, 1989

From: CVAX::JLOCKMAN 5-JUN-1989 14:38
To: ABRIDLE
Subj: Comments on feeds and optics meeting

Here is a my personal summary of the results of the meeting on feeds and optics in Green Bank on June 1.

(1) In the normal course of operations there will be regular movements of receivers and feeds on and off the GBT. Put another way, a "revolver" of receivers at the cassegrain focus, while desirable, will not provide complete capabilities. Thus we must plan for easy, routine access to the primary and secondary focii.

(2) A vast majority of those present thought that many if not most L-band observations should be done at the prime focus. On thie view, an f/D of 0.4 is much preferred over an f/D of 0.3.

(3) Requirements on the subreflector as it is now specified (diameter >=8 meters, rms=70 microns, capable of nutating at >1 Hz) seem formidable. Moreover, the subreflector will have to be removed regularly (at least quarterly) to clear the area for prime focus observing. It is important to determine how many of these properties are essential. In particular, when is nutation absolutely necessary?

(4) Whether they are located at the prime or secondary focii, multi-beam receivers below 5 GHz will be large and cumbersome. Some equipment (e.g. the subreflector or parts of the "revolver") will probably have to be removed to accommodate them.

(5) It might be desirable to plan for cassegrain operations only over the range 5-22 GHz, for example, and do the higher and lower frequencies at prime focus. Perhaps several receivers could be built in one high/low frequency system so that switchover would be rapid. This would reduce requirements on the subreflector by a bit.

PERSONAL RECOMMENDATIONS

(1) The Observatory's expertise in instrumenting, maintaining, and supporting observations on a telescope like the GBT is mainly concentrated in the personnel of the Jansky Lab. There is considerable astronomical expertise there also. We should plan regular meetings in Green Bank to ensure that our design does not depart from either practicality or the needs of the science. Our next meeting could involve more of our scientific staff and concentrate on the need for nutation.

(2) Many of the conflicting demands on the telescope's optics are removed (in principal) in an unblocked telescope. Having the single arm at the "bottom" of the dish (or allowing elevations to 180 deg.) insures easy access to the focii and greatly reduces maintenance logistics. But as yet we have done no work on the possible optics of an offset telescope. I suggest that this be given highest priority.

From: CVAX::PJACKSON "Phyllis Jackson" 8-JUN-1989 10:17
To: @MIXSTAF.DIS
Subj: Memo from G. Seielstad

From: CVAX::GSEIELST 7-JUN-1989 17:44
To: PJACKSON
Subj: Proposal for Green Bank Telescope

You are invited to read first drafts of the proposal under preparation.
All contributions are stored in CVAX. Enter UMA3::[GSEIELST.PROPOSAL].

The individual chapters inn the probable order of appearance are listed below, with their authors. If you have comments, please send them to George Seielstad. Of course, you may wish to discuss them with the authors, too.

We are on a fast track now, so, if your comments are to be considered, they must arrive very quickly (within a week?).

1) Introduction Seielstad
To be written, after the rest of the proposal is assembled.

2) Science Condon
Presented in 6 sections in the aforementioned UMA3 directory. Each section looks like SCI1.TEX;7 for example.

3) The Antenna D'Addario
First look at ANTENNA.README;1, which will instruct you how to see the actual text.

4) Electronics Norrod
File is ELECTRON.TXT;3

5) Monitor and Control Lacasse
Text in MONCTRL.TXT;3
A block diagram is in MCBLK.DWG;1

6) Data Processing Liszt
File is DATAPROC.ASC;1

7) Site Hogg
File is SITE;TXT;2

8) Operations Lockman
File is OPERA;TXT;1

9) Budget, Schedules, Staffing Vanden Bout
Not yet written.

From: CVAX::ABRIDLE 23-JUN-1989 13:25
To: AZENSUS,CWALKER,ABRIDLE
Subj: VLBA-11

Things are getting serious. The House and the Senate both passed the bill that funds the eleventh, very large, element of the VLBA a.k.a. the new Green Bank Telescope. All it needs now is Bush's signature.

From: VAX1::VAX3::JWROBEL 24-JUN-1989 12:00
To: ABRIDLE
Subj: VLBA-11

Alan,

I liked your description of the new Green Bank telescope as VLBA-11!

Cheers,
Joan

From: CVAX::ABRIDLE 24-JUN-1989 22:16
To: VAX1::VAX3::JWROBEL,ABRIDLE
Subj: RE: VLBA-11

Yeah, Jay Lockman has an alternate cover design for the proposal. It's the number 11 in a red circle with a diagonal bar through it.

But aren't we glad we put the North-East antenna in New Hampshire now?

Cheers :) A.

From: CVAX::ABRIDLE 29-JUN-1989 00:24
To: BBROWN,FSCHWAB,ABRIDLE
Subj: Comments on BRD doc

Here are some minor items from my reading:
p.2 last para Is it terue to say adding short uv spacings to VLA will increase dynamic range? I don't immediately see why. It also won't increase fuield of view per se (can already image wide fields full of point sources) but rather the largest angular scale of structure that can be imaged?
p.6 section 1.5 The BRD will not be "added to the VLBA", but will occasionally be used in combination with it? i think there's a distinction, and the spectroscopists will be especially sensitive to it!
p.35 Section 6,2 Not true that core-dominated QSR jets align well between parsec and kiloparsec scales (as seen by observer). In fact, standard interpretation of the relationship makes use of the observation that there are large misalignments for these objects!
p.57 first para implies that NRAO will provide state of the art technology despite the need for it!. Delete "nevertheless" ? Also, radical advabnces in technology will not be so much rare as longer-term? How about :as the telescope will be constructed rapidly, we do not expect to see radical advances in capability during the construction period.
p.65 Section 4.1 the "spectral processor will *likely* be made available"? Surely it *will* be available for any projects for which it is needed and the BRD is better suited than the 140-ft.
p.71 Section 4. Much sound and fury signifying nothing?
p.73 Section 5. Not obvious to me how adding a network server increases security. Is this supposed to be obvious? (If the remote observers can control the telescope through the server, then it seems to me they can also do "inadvertent, malicious or illegal" things through the server.
p.76 Pulsar search mode - some formatting probelm at end of line 3.
p.79 bottom. Some discussion of relation to other NRAO large-scale computing plans needed here?
Operations Section. More a promissory note and motherhood than a plan, here? Again some discussion of integration, new costs ($ and people) needed ? Possibly the budghet section addresses these?

Overall - good value for money at $750k of funding per page ?

From: CVAX::ABRIDLE 29-JUN-1989 11:03
To: VAX1::VAX3::RPERLEY,ABRIDLE
Subj: RE: Newsletter

It's a sad comment on the fragmented state of the observatory that a $75M project that will keep Green Bank in business well into the 21st Century gets no attention in New Mexico. Still, the West Virginia, Virginia and Arizona staff have all been heavily involved, so maybe it also speaks to our strength as well - we can get a project like that going with only Peter Napier and Lee King from NM paying much attention to it.

From: CVAX::ABRIDLE 5-JUL-1989 15:16
To: BCOTTON,ABRIDLE
Subj: VLBA-11

According to the Charleston, WV, Gazette, President George (Burning) Bush of "don't do nothing to ma flag" fame, has signed the bill authorizing $75M of all-new add-on funds for the new Green Bank telescope.

The Supreme Court also decided that Christmas creches outside government buildings are unconsitutional, but combinations of Christmas trees and minoras are not.

Come back soon before we all go crazy.

Yrs, Alan

From: CVAX::JLOCKMAN 7-SEP-1990 12:03
To: @SWG.DIS
Subj: Shaped Reflector Performance

Roger Norrod has written a memorandum, in the mail to you now, summarizing the comparison between dual shaped reflectors on the GBT and conventional optics. A shortened version of his memo is provided below to assist the SWG's discussion on September 12, 1990.

The use of dual shaped reflectors allows the designer to achieve an arbitrary field function in the antenna aperture plane. The technique is usually used to make the aperture field more uniform than that achievable with the conic section reflectors. From Fourier theory, it then follows that the boresight gain will increase, the beam will become more narrow, and the near sidelobes will increase. Table 1 gives the diffraction analysis results for the unshaped and three shaped reflector cases. The unshaped case used a feed pattern tapered 12 dB at the subreflector edge. The shaped reflectors all used feed patterns tapered 16 dB at the subreflector edge. The Gaussian case had a Gaussian aperture pattern, tapered 16 dB at the main reflector rim. The two other cases had aperture patterns uniform to 60 and 80 percent of the aperture radius, and then a Gaussian taper to -16 dB at the main reflector rim. It is undesirable to attempt a completely uniform aperture pattern, because of problems with spillover, but it should be possible to achieve aperture efficiencies approaching 90 percent with the dual shaped clear aperture antenna.

Table 2 shows the aperture efficiencies of the same four reflector systems as the feed is displaced from the focus position. The beam displacement is given in number of FWHM beamwidths. As can be seen, the increase in peak aperture efficiency of the shaped systems is achieved at the sacrifice of field-of-view. This effect was discussed by Napier in NLSRT Memo No. 46, and seems to be unavoidable.

It should be noted that even though the Gaussian shaped reflector has peak efficiency approximately equal to that of the unshaped reflector, this was achieved with a feed pattern having significantly greater edge taper, a not insignificant advantage. It should also be emphasized that only a small number of aperture functions have been studied. However, it seems unlikely that an aperture function can be found that achieves simultaneous large peak efficiency improvements and a field-of-view usable out to even three beamwidths.

TABLE 1

Antenna Performance

	Peak Efficiency	2 GHz Beamwidth (arc min)	First Sidelobe
Unshaped	72%	6.3	-27 dB
Gaussian	72%	6.4	-28 dB

Uniform to 60% Radius ...	78%	6.1	-19 dB
Uniform to 80% Radius ...	84%	5.7	-18 dB

TABLE 2

Efficiency for Displaced Beams

Beam Displacement	Unshaped	Gaussian	Uniform 60%	Uniform 80%
0	72%	72	78	84
3	70	68	59	51
6	65			
10	60			

From: CVAX::JLOCKMAN 7-SEP-1990 12:21
To: @SWG.DIS
Subj: About the previous memo

The mail message you just received about shaped reflectors is a copy of a message that I received from George Seielstad this morning. It is probably safe to say that Roger Norrod's full memo on the subject is NOT in the mail to each of you, but is only coming to me. If you wish to see the full item please let me know and I'll get you a copy.

--Jay

From: CVAX::GSEIELST 21-DEC-1990 11:21
To: @SWG.DIS
Subj: NSF Press Release

The National Science Foundation released the following Press Announcement on December 19:

GREEN BANK TELESCOPE CONTRACT AWARDED TO RADIATION SYSTEMS, INC.

A $55 million contract to design, construct and test a new National Science Foundation radio telescope at Green Bank, West Virginia, has been awarded to Radiation Systems, Inc. (RSi) of Sterling, Virginia.

The award was made Wednesday (December 19) by Associated Universities, Inc. (AUI), a not-for-profit corporation that operates the National Radio Astronomy Observatory (NRAO) for the National Science Foundati cooperative agreement. RSi is an experienced builder of radio antennas and is currently completing the construction and erection of the ten units of NRAO's Very Long Baseline Array (VLBA), a coordinated network of radio antennas stretching from Hawaii to the Virgin Islands.

The Green Bank Telescope (GBT) will be the largest fully-steerable telescope in the world. It will have a lasting impact on our understanding of the universe due to its sensitivity and sophisticated electronic equipment.

After the collapse of an aging 300-foot telescope at NRAO's Green Bank site in November, 1988, NRAO proposed to replace it with a state-of-the-art, fully-steerable, 100-meter telescope. In 1989, the Congress appropriated $75,000,000 to build the new telescope.

The GBT will be built near the former location of the 300-foot telescope. The site had originally been selected for its location in the National Radio Quiet Zone, an area uniquely protected from radio emissions that might interfere with the operation of radio telescopes.

Studies of radio emissions permit astronomers to learn about astronomical objects and phenomena that cannot be well-understood through optical astronomy alone. For instance, the GBT will contribute to astronomers' understanding of the timing and regularity of pulsars, dense, rapidly rotating stars that emit narrow beams of radio energy.

Researchers should also be able to learn more about the chemical content and evolution of young galaxies. In addition, the GBT will be used to study radio emissions from the sun's surface and throughout its entire corona, providing observational data with which to test theories of solar physics.

Radio wavelengths are longer than those of visible light, requiring radio telescopes to be bigger in order to obtain the same resolution as optical telescopes. While the orbiting Hubble Space Telescope permits astronomical observations at optical and ultraviolet wavelengths to be made without the distorting effects of Earth's atmosphere, it was not designed to cover the radio spectrum.

When operated in conjunction with other radio telescopes, such as the VLBA, the GBT will greatly increase the power of the combined network, thus making possible the observation of far more distant objects. Later in the decade, when radio antennas are scheduled to be placed in orbit, the world-wide network of radio antennas will simulate a telescope larger than Earth.

Ground-breaking in Green Bank is planned for early Spring 1991. Assembly and installation of the telescope will begin in 1992, and will be completed in 1994. Astronomical observations are scheduled to begin in 1995.

As designed, the GBT will be the first large telescope with an unblocked aperture, a feature that eliminates a significant portion of internal and local ground interference. GBT also will have a reflecting surface that can be adjusted to optimal shape during operation. This will be achieved by means of computer-controlled corrections to the position of the individual reflecting panels.

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