Interoffice

National Radio Astronomy Observatory

Green Bank, West Virginia

May 22, 1980

To: Addressee

VLB ARRAY MEMO No. 1

From: K. I. Kellermann

Subject: VLBA Design Study

I would like to proceed with the design effort on the VLB Array as follows:

The 1977 study needs to be brought up-to-date taking into account new concepts as well as experience gained from VLA and VLB operations. In particular, various cost-performance tradeoffs need to be evaluated.

Considerable progress has already been made in a number of areas as a result of informal discussions, various internal memoranda and reports, efforts made in connection with the Caltech study, and the continuing use and development of the VLA. I would like to have all new contributions in a preliminary form by the end of July at the latest. This will then form the basis of a Preliminary Design Study which I will try to complete by the end of August and make available for distribution to the community. This time scale is set by the desire to respond to a request from the NSF for a "Conceptual Proposal" in time to be considered by the NSF Astronomy Advisory Panel in developing the NSF long-range plans for astronomy, and to permit a broader discussion with the community at a "VLB Array Workshop" at the time of the next NRAO Users Committee. At this time we should plan to reach tentative agreement on the performance specifications of the Array, and then together with outside participation a more detailed and specific proposal can be prepared in time for NSF consideration for FY 1983 initial funding.

The enclosed outline and supplementary notes indicate the main points which need to be addressed in the Preliminary Design Study, together with the names of people who have indicated a willingness to be responsible for various areas. Please let me know if I have missed anything or misinterpreted your intentions.

If you will send your contributions, ideas, questions, comments, criticisms, thoughts, etc. to me, I will assign them a running number and recirculate them among the Design Group. The more complete your contribution, the easier it will be for me to use it, but I will accept less-than-well-prepared written reports such as the results of calculations, computer simulations, correspondence with outside experts, etc. Please do not wait until the July deadline if you have material before that time.

I also enclose a numbered list of previous reports and memoranda which appear relevant. Copies are available from the authors. Let me know if I have left anything out.

VLB ARRAY DESIGN STUDY

I. SUMMARY

II. SCIENTIFIC GOALS

- A) Capabilities and Comparison with VLB Network
- B) Radio Galaxies and Quasars
- C) Galactic Sources
  - 1) Molecular Masers
  - 2) Stellar Objects
  - 3) Galactic Center
- D) Interstellar and Intergalactic Medium
- E) Solar System
- F) Astrometry and Distance Determination
- G) Geodesy and Geophysics
- H) Other Applications

III. BACKGROUND

IV. IMAGE FORMATION

V. DESCRIPTION OF THE ARRAY

- A) Sensitivity, Resolution, Wavelengths, Sidelobes, Dynamic Range
- B) The Configuration
- C) Antennas
- D) Feeds
- E) Front Ends
- F) Control and Monitor System
- G) Correlator System
- H) Post Processing and Image Formation

VI. SITE DEVELOPMENT

VII. OPERATIONS

- A) Philosophy
- B) Array Operation Center
- C) Correlation Center
- D) Maintenance and Repair
- E) Circulation of Tapes

VIII. COSTS

- A) Capital Cost
- B) Construction and Funding Plan
- C) Operating Cost

3) Same as (2) for alternate designs (i.e., wheel and track) and manufacturers.

4) Should reflector be more shaped than VLA dishes to increase efficiency? What are penalties?

5) Cassegrain vs. Gregorian systems.

D) Feeds (Napier, Fisher)

1) Multiple VLA type feeds vs. fewer broad band feeds.

2) Improved efficiency at 20 cm.

3) Long wavelength (50, 92 cm) operation, prime focus or secondary.

4) Feed selection, VLA type or other (i.e., on axis rotating mirror).

E) Front Ends (Balister, Weinreb)

1) Cost vs. reliability and performance; consider.

a) Room temperature GASFETS

b) Cooled "

c) Cooled GASFETS plus maser preamp at 0.7 and 1.3 cm

d) Maser-upconverter systems

e) Wavelengths

i) Basic 1.3, 2.8 (or 2), 6, 18-21 cm, 50 cm.

ii) Desirable 92 cm, 0.7 mm, 3.8 and/or 13 cm.

F) Control and monitor System (Balister)

1) Requirement and Cost including transmission facility for:

a) Antenna control including feed, front end, back end configuration.

b) Receiver and weather monitoring and logging

c) Real time fringe verifier

d) Computer requirements at site and at Operations Center

e) Telephone lines vs. satellite link (Weinreb)

VLB ARRAY DESIGN STUDY

(Supplementary Notes)

SECTIONS I, II, III, IV -- (KIK)

SECTION V. The Array

A) Including potential future expansion, assume 10 antennas — (KIK)

B) Configurations -- RCW, WC, FS)

1) Evaluate configurations using CLEAN and/or self calibration as well as conventional transforms.

2) To what extent is the Array coherent, i.e., what is the sensitivity per pixel on weak (i.e., no fringes detectable in fixed integration period), strong (fringes detectable all the time on all baselines), and intermediate strength sources.

3) Evaluate Array configurations by using real VLA sources.

4) How good are self-calibrated maps compared with ones made from perfectly calibrated data.

5) Using artificial and VLA sources, compare maps made with present VLB Network at both long (18 cm) and short (1.3 cm) wavelengths with those made using the Array.

6) Consider the use of an element(s) in Canada, particularly Newfoundland.

7) Consider the use of an element in Europe (Italy).

8) " " " " " " " Green Bank, VLA, Tucson.

9) " " " " " " " Puerto Rico.

10) Are redundant baselines important (necessary?) for self calibration?

C) Antennas (JWF, WW)

1) Cost of E-Systems antenna. Cost of other comparable antennas.

2) Cost and specifications of improved E-Systems antenna (i.e., modified base, yoke arm, surface). Design goal $\lesssim$ 0.4 mm r.m.s. about best fit parabola, $\pm$ 6" r.m.s. non-repeatable pointing error for operation at 7 mm.

SECTION VI. Site Development (HH)

1) Assume 5 existing sites, 5 new sites

2) Building requirements (for antenna control, backends, recorders, routine maintenance, tape storage and shipping, etc.

3) Power, roads, vehicles (for tape transport to nearest commercial facility).

4) Do we need cherry picker or lift?

Section VII. Operations (HH)

1) Site personnel; duties, how many required.

2) Central Personnel

   a) Processor Operation (duties, number)

   b) Array Operation (duties, number)

3) Are telescopes controlled in real time from A. O. C. or by local computer which is periodically updated from the A.O.C.?

4) Maintenance and repair, spare parts at the A.O.C. and field sites.

5) Scheduling and observing

6) How are sites managed?

   a) new sites, new antennas

   b) old sites (non NRAO), new antennas

   c) " " (NRAO), new antennas

   d) " " , old antennas (e.g. OVRO).

7) AAA (Array Associate Antennas), relationship and coordination with Array (KIK)

   a) Canada, Bologna, MPI, Arecibo, VLA, 140-ft.

8) How many processors are needed?

9) How are tapes transported?

10) Where is A.O.C.?

   a) close to most antennas (VLA?)

   b) GB or CV

11) How is post processing handled?

G) Local Oscillator

1) Frequency standards maser or other, e.g. SCCO (KIK)

2) Satellite link (KIK)

3) Generation of flexible l.o. signal at all bands with $\leq$ 1 MHz resolution (Balister)

4) IF and/or RF phase calibrator (Balister).

H) IF Distribution and Data Recording

1) Tape Recorder Systems (KIK)

a) Broad band vs Multi track narrow band

b) Potential Record times

2) Alternate Recording Schemes (Burns)

3) Direct data links

a) Satellite (KIK)

b) Land lines (Weinreb)

I) Correlator System (KIK)

1) Number of channels

a) Spectroscopy

b) Continuum, including polarization

2) Number of input stations; 10, 11, 12?

3) Clock rate, LSI vs. standard IC's, station vs. baseline modules.

4) Hardware fringe fitting and FFT

5) Computer and software requirements (Hjellming, Burns, Clark(?))

J) Post Processing Requirements (Hjellming, Burns, Clark(?))

1) Calibration of data

2) Sorting of data

3) Mapping, including self calibration, CLEAN

4) Archiving and Display

5) Computer and software needs

SECTION VIII. Costs (HH)

1) Summary

2) Construction and funding plan

   a) Should one antenna be built first to get experience?

   b) Should a prototype Processor be built prior to actual Array development?

3) Software development

   a) Control and monitor systems

   b) Processor

   c) Post Processing

4) Operating Cost

   Personnel
   Shipping
   Communications
   Materials and Supplies
   New Equipment