VLB ARRAY MEMO No. 161

NATIONAL RADIO ASTRONOMY OBSERVATORY

MEMORANDUM December 17, 1982

To: K. Kellermann, M. Balister

From: C. Moore

Subj: Ball Aerospace MRAS Concept for the VLBA

I have reviewed the various "white papers" submitted by Ball for a small dish array alternative (MRAS) to the proposed 25 m antenna for each VLBA site. I have concentrated by attention on the details of the latest version put forth in a letter from K. Shoemaker of Ball to Dr. B. Burke (dated 29 September 1982).

Basically, I cannot see that this is a viable alternative from technical as well as cost viewpoints. The scheme would not provide comparable sensitivity; would involve considerable technical development and risk; and would be more expensive to field and maintain. My detailed comments are:

1) Surface tolerance ± 1.3 mm

Using the standard criterion of $\lambda/16$ for maximum frequency of operation, these dishes should only be good to 15 GHz. It is doubtful that they would achieve an aperture efficiency of 0.65 at 46 GHz.

2) Pointing accuracy 2 arc-min

At 43 GHz this is 1/3 half power beam width (HPBW). Using the standard criteria of non-repeatable pointing errors less than 1/10 HPBW, these dishes should only be good to about 15 GHz. Even with no errors in electronic steering, the single beam gain at 43 GHz will degrade.

3) Sensitivity

Table I indicates that the proposed VLBA will be more sensitive by factors of 2 to 3 except at the longest and shortest wavelength. However, it is doubtful that MRAS will achieve 0.65 efficiency over the entire frequency range (especially above 15 GHz) and also that a 125 K T_{sys} will be achieved with a GASFET at 43 GHz. The 1986 projection by NRAO for a GASFET cooled to 20 K at 43 GHz is 200 K receiver temperature (not system temperature).

4) Cryogenics

Any Joule-Thomson cooler is limited in mean-time-before-maintenance by the purity of the refrigerant gas used and the cleanliness of the refrigerant path. Eventually contamination build-up will throttle gas flow and necessitate warm-up for decontamination. This is a significant consideration for field operational systems. Additionally, the compressor for use with the MMR Technology refrigerator must handle high pressures (several thousand psi) and is presently under development but not available commercially. Thus, actual field use reliability is not known. The cryogenic system proposed for the VLBA has

4) Cryogenics (continued):

been in field use for over 15 years and its problems are well known. While the innovation in the MMR Technology approach shows promise, it has not matured to the point where the fielding of 270 units (27 units at each 10 sites) is prudent.

5) Cost

While the per element cost of the MRAS may be low, the net cost of fielding such a system must consider maintenance (can 2 full-time equivalent people maintain 27 elements?), spares' provisioning (27 times more spare modules than in the VLBA proposal), and site acquisition (25 acres per site instead of 3/4 acre for the VLBA as proposed).

TABLE I

Comparison of VLBA NRAO Proposal and MRAS (Burke)

MRAS				VLBA Proposal		
λ	Freq.	T_{sys}	Sens.[1]	Eff.	T_{sys}	Sens.[2]
cm	GHz	K	mJy		K	mJy
0.7	43	125	710	0.36	75	830
1.36	22	120	680	.61	45	290
1.96	15	115	650	.67	65	385
2.90	10.7	110	620	.70	45	255
	8.4	-	-	.71	40	225
5.98	5.0	118	670	.69	37	215
13.60	2.3	117	660	.69	31	180
18.0	1.7	117	660 } →			
21.0	1.4	117	660 } →	.58	29	200
44.6	.611	117	660	.47	55	465
90	.325	117	660	.31	70	900

[1] τ = 1 sec, Tot Pwr Rx
BW = 2 MHz, Eff. = .65,
27 - 5 m diameter dishes

[2] τ = 1 sec, Tot Pwr Rx
BW = 2 MHz, Eff. as listed,
1 - 25 m diameter dish

$$\text{Sensitivity} = \frac{2\,k\,T_{sys}}{A_c\sqrt{B\tau}}$$

$$k = 1.38 \times 10^3\ \text{Jy} - \text{m}^2/{}^\circ\text{K}$$

$$A_c = \frac{\pi D^2}{4} \times \text{Eff.} \times \text{No. Elements}$$

CRM/cjd