Interoffice

National Radio Astronomy Observatory

Socorro, New Mexico

March 11, 2003

To: Peter Napier

From: Jon Romney

Subject: Cost Estimate for VLBA Integration in EVLA Phase 2 Proposal

At your request, I have estimated the costs of partially integrating the VLBA into the EVLA within the Phase 2 project. I called on the expertise of many NRAO and DRAO personnel with diverse backgrounds, primarily: Brent Carlson, Dave Fort, Mike Revnell, Michael Rupen, and Craig Walker. In addition to numerous bilateral discussions, I organized two very useful teleconferences, which also included Steve Durand, Rick Perley, and Bruce Rowen.

I refer to "partially integrating" above to describe groundrules you gave me, that this part of the EVLA Phase 2 project should provide for recording and correlation of an integrated NMA-VLBA instrument, at an instrumental level to match what we expect the VLBA to have reached by 2009 – 2010. I did not include any upgrades to the 8 VLBA stations which will not become part of the NMA. And, on the same basis, I decided to target a recording rate of 4 Gbps, which is the most that could usefully be provided by sampling the VLBA IFs using EVLA sampler units, without a major upgrade to the non-NMA VLBA stations.

My cost estimate also assumes that Mark-5-like playback units can be accommodated in the EVLA correlator screened room. Originally, the discussions I held favored a location outside the room, with signals being input to the correlator on optical fibers. However, the required interfaces proved to be fairly expensive, and at the same time it was determined that both input and output VSI connectors could be accommodated on the Widar station board. ("VSI" is the VLBI Standard Interface, adopted recently, to which the Mark 5(B) recording system will conform.) This will require that the Mark 5 units be located in the screened room. I discussed the correlator room layout with some of our technical staff, and it is expected that there will be room for these recorders if "only" a 40-station correlator is built. You and I also discussed a possible fallback, locating these in another screened room, connected by a screened conduit.

The cost estimated is presented in the attached Table 1. The following comments provide some necessary explanations to some of the items, keyed by the serial number in the left-hand column.

1 – 2] Widar station boards for sub-banding; backplanes & VSI connectors. The wideband EVLA signals from the ten NMA stations will have to be filtered to the narrower bandwidths before recording. We considered designing a special-purpose filter module, but decided it would be least expensive to use the FIR filters which are a major function of the standard Widar station boards. It may be possible to reduce the cost of these boards marginally by omitting unnecessary components. Two such boards are required for each station, to process widely separated subbands observed in dual polarization. *The budgeted cost includes parts and assembly, but not the overhead that will have to be negotiated between NRAO and DRAO.* Each board will have both input and output card-edge connectors, to support VSI output to a recorder, and VSI input from a playback. These connectors will mate with a special-purpose backplane to break out the VSI signals to separate MD-80 connectors as required by the VSI specification.

3 – 5] Mark 5 recorders; disk modules; & playbacks. The cost of the advanced, 4-Gbps Mark 5 recorders, disk modules, and playbacks that it will be appropriate to use in 2009 – 2010 is quite difficult to estimate. Currently, we are not quite ready yet to deploy the 1-Gbps system that has been under development in recent years. This system is based on commercial, mass production disk drives, and we anticipate a strong, consumer-driven evolution in the capacity.

As a best approximation to the cost for a 4-Gbps record/playback system, I have used *twice* the commercial price for current Mark 5 orders, assuming that an extra factor of 2 in capacity will be achieved as predicted by "Moore's Law". The cost of an 8-drive disk module assumes all the following: 30-day media pool; 10 stations (i.e., NMA only); 4 Gbps record/playback rates, at 50% activity factor; individual disk drive capacity 2 TB; disk drive cost 6¢/GB; 12.5% overhead for the module housing, and signal and power cabling. These same cost elements were used in a previous analysis I did for Craig Walker's EVLA Memo #50.

6] Optical splitters & switches. These are required for two different purposes. The smaller complement, 60, splits the inputs from 10 NMA stations, 2 bands with 3 fibers each, to both the correlator and to the special NMA sub-banding Widar boards. The remaining 216 provide 18 nodes, of 2 splitters and 2 switches on each of 3 fibers, to route the signals from the 37 real-time EVLA+NMA stations within the correlator so as to maximize the resources available for simultaneous correlation of real-time and VLBI observations.

The estimate includes *no* labor components. Engineering required at DRAO is being absorbed in EVLA Phase 1. Engineering at NRAO would be limited to laying out a rack for items [1] & [2], and is considered negligible. Software development costs could be substantial, but are included explicitly in the separate estimate by T. Cornwell.

Table 1.

EVLA Phase 2

Cost Estimate for VLBA Integration

#	Item	Units	Unit Cost k$	Total Cost k$	Fraction	Comments & explanations
1]	Widar station boards for sub-banding	20	15.0	300	13%	20 = 2 per NMA station to support widely-separated sub-bands
2]	Backplanes & VSI connectors	60	2.0	120	5%	60 = (40 in correlator) + (20 for NMA subbanding)
3]	Mark 5 recorders for NMA stations	10	32.6	326	14%	
4]	Mark 5 disk modules	405	1.1	437	19%	/ Capacity: 8 X 2TB 16 TB < Module: Capacity X $0.06/GB + 12.5% $1,080 \ Pool: 10stn X 30days X 50% @ 4Gbps / Capacity 405 modules
5]	Mark 5 playbacks for correlator	26	32.6	848	36%	26 = (40-27)*2; accommodates VLBA + NMA + [VLA&GBT | 3 VLA arm subarrays]
6]	Optical splitters & switches	276	0.5	138	6%	276 = 3 X [10 X 2 + 18 X (2+2)]
7]	Spares			173	7%	10%, *excluding* disk modules
	Total			2,342	100%	

03/3/11 -- jdr