Response to the EVLA Advisory Committee Report of 10/11 June, 2002

6/06/2003

The NRAO Director wishes to thank the members of the EVLA Advisory Committee for their time and hard work at the meeting and for the valuable advice which they provided. These responses are made under the same headings as the headings contained in the Committee's report.

Project Overview

We agree that it is important to maintain the project schedule and if possible speed up the completion of the project. This point has been made to the NSF in project presentations and progress reports but has not yet resulted in increased funding appearing in the NSF budget plan for NRAO for 2004 and beyond. We will keep trying to get accelerated funding.

Design Goals and Science Drivers

We agree that coupling between science drivers and design goals is not specific. We are working to clarify and review the connections. A memo is being prepared which will detail how each design goal was decided, and its connection to the science goals. In addition, a review of these connections will be undertaken, and a report scheduled to be completed by the end of July. We will summarize progress in this area at the upcoming EVLA Advisory Committee meeting in September.

We will address the issue of RFI mitigation in the post-processing later in this response.

The Committee is concerned that there is no apparent connection between science drivers and the e2e development. The specific example of an absence of research into new imaging algorithms is highlighted. As part of an ongoing reorganization of the management of its scientific software work, NRAO is planning to establish a Working Group for such algorithm development. Currently there are insufficient funds in the Phase I budget to fund this work, but if contingency funds are adequate later in the project some of this work may be funded. The Phase II budget includes money for funding such work.

Systems Overview: Hardware

The cost estimates for several of the electronic subsystems have decreased in recent months due to decisions to use custom MMICs, surface mount components and multifunction modules as suggested by the Committee. In particular this approach has reduced costs for the high frequency receivers, the U/X converter and the IF down converter. The use of diode switches instead of mechanical switches is being actively pursued with sample MMIC diode switches about to be tested.

An interaction with the engineering group at CICESE was initiated. However, a recent decision by the Mexican funding source that the Mexican funds cannot be used for development work makes it less likely that the CICESE group will do EVLA work.

System Overview: Software

It was pointed out that the software effort is fragmented and that groups are not communicating. We have intensified communication between M&C and e2e, are conducting monthly coordination meetings, and are developing a road map of what elements of the M&C software and the e2e software will be needed when to support the various stages of the hybrid array. Though we see our correlator-related schedule as more relaxed during the first years of the project, we have increased our communication with the correlator group in Penticton through weekly phone meetings and occasional visits. Finally, local communication and collaboration between the M&C software and hardware groups is frequent and fruitful.

As for the hiring difficulties, we are happy to report that we managed to fill all vacancies with qualified people, allowing us to make progress on fronts that had previously received insufficient attention.

In view of the limited staffing at the time, the committee suggested we closely examine the ALMA Monitor and Control System for possible use. Though we are pessimistic about wholesale adoption because it requires processing power on the order of a VME crate at each antenna, with RFI characteristics unacceptable to the EVLA, we are exploring the ALMA Common Software (ACS) for use both in the EVLA M&C interfaces to the e2e software and for possible use within the EVLA M&C System itself.

The committee believes that the potential of e2e for success is questionable due to leadership (based on AIPS++ problems). NRAO is currently completely reorganizing the management of its AIPS++ and e2e work, with a primary goal of the reorganization being to give the Projects (EVLA and ALMA) more direct control of the work.

With respect to involvement of users in e2e development, an e2e project scientist (Dale Frail) has been appointed.

As noted in more detail below, all necessary Scientific Software Requirements documents have either been completed or will be completed shortly.

Antennas & Feeds

Completed tests of a scaled model of the L band feed show that achieving the octave bandwidth is feasible. A feed layout design that reduced shadowing of one feed by another to acceptable levels as determined by calculations has been achieved. A mounting mechanism to allow accurate pointing of the feeds has been designed and

prototyped. Further, more detailed, cost estimates for the large L and S band feeds showed that they were under-budgeted and the budget for these items was increased.

Receivers

For solar observing a system providing switchable attenuation and calibration signals has been designed and will be tested on the prototype receivers. The system will require the solar observer to determine when to use the flare or quiet sun settings. The attenuation required for flare observations is sufficiently large that it will not be possible to calibrate using normal astronomical sources so the change in gain and phase when switching to flare mode will be measured in the laboratory and applied as a correction during solar observing. It is not currently expected that it will be necessary to ease other system specifications, such as gain variation with frequency, when in flare mode.

LO and IF

The block diagram has been completed and on the issue of headroom the allocation of the system gain budget has been made and, with respect to the 1 dB compression point, headrooms of 34 dB at L Band to 20 dB for the high frequency bands should be achieved.

Tests of the relative phase stability of pairs of fibers, perturbed both by temperature variations and mechanical bending in a cable wrap, have now been made using the actual fiber cables purchased for the EVLA. The tests show that performance is adequate to allow a round-trip-phase measurement when separate fibers are used for the out-going and return paths.

We agree that self-generated RFI is a significant concern for the project. Tests have now been made on the levels of RFI generated by most of the digital equipment to be located at the antenna and on the shielding levels provided by the specially-built RFI-tight and absorbing enclosures. It currently appears that self-generated RFI can be kept within acceptable levels, although this aspect of the design will need continual attention.

We have followed the Committee's advice and are using surface-mount and chip MMICs throughout the electronics system. This has indeed reduced the cost estimates for much of the electronics.

We thank the Committee for pointing out the problem with the phase-stability specification for the L Band up-converter. We had overlooked this requirement and have now changed the specification to a more suitable value. This has made the phase stability requirement for the LO synthesizer very difficult. A fall-back position would be to make use of the fact that the EVLA has sufficient sensitivity so that in all bands up to X Band there will always be a phase calibrator within the field of view so that slow variations in phase can be self-calibrated away.

Correlator

The Canadian Government has now committed funding to the Herzberg Institute for Astrophysics (HIA) to construct the correlator. The issue still remains of whether every desired feature of the correlator can be provided within the available funds. This should become clear shortly as fabrication of prototype correlator equipment is beginning.
We agree that it is important that the capabilities of the hardware and software systems surrounding the correlator be matched to the correlator capabilities. Both HIA and NRAO M&C groups have software engineers in their teams with specific responsibility for correlator software. NRAO is already prototyping the computer cluster which will provide the interface between the back-end of the correlator and the archive. Comments on e2e are included below.

Radio Frequency Interference

This is certainly a serious issue, particularly at L-band and below. Our response to the 5 suggestions:
1) Intermodulation assessment. This analysis has been done, although more by tracking the 1% compression point through the system than the IP2 and IP3 levels. Using this analysis high power amplifier and mixers were used at appropriate places in the signal chain to keep the dynamic range high. At L Band the predicted head room with respect to the 1 % compression point is 22 dB.

2) DME Filter. We have followed the committee's suggestion and divided the L Band LNA into two gain blocks separated by connectors so that a switchable filter can be inserted if necessary. The decision to install such a filter will be made based on experience on the test antenna.

3) DME Pulse Blanking, or very fast AGC. We are looking into blanking the digital data when the amplitude exceeds a set threshold. There are three possible places in the system where this could be implemented. Of course, the correlator must be informed of the amount and distribution of the blanking, so that appropriate corrections can be made. We are in the process of coordinating this interface between the correlator and the rest of the electronics system.

4) Frequency selection at first stage of the correlator. This is possible, via a fast look-up table of tap weights, to reduce the power in a known, strong interfering signal. The spectral resolution would not be very high, but the signal in the wings should be recoverable. We are looking into how this might be implemented. We will discuss this approach with the correlator group.

5) Postcorrelation mitigation schemes. It is clear that this evolving methodology is the last line of defense against moderate-level RFI. An external source of RFI is no different than an unwanted strong astronomical source. We have long ago developed methods for removing such unwanted signals -- these are routinely implemented in low frequency

observing. There is no fundamental reason why this methodology will not work for the EVLA's needs.

However, it is clear that such processing will be expensive, as the signal must be sampled very quickly (very much faster than the fundamental fringe rate) to preserve the interfering amplitude and phase. After removal of the signal, the data can be averaged down to more manageable volumes.

A memo is being prepared (by Perley and Cornwell) on the subject, and will set out the estimated costs in storage and software for detailed removal of unwanted extraneous signals.

We have not yet been able to find any person to assign to more detailed studies and simulations. At this time, it is most important to ensure that the system remains linear, and that the time sampling be as fast as practicable, in order to enable studies and implementation of effective post-processing signal subtraction in the future.

Monitor and Control

Though we have not yet finalized the overall design for the system, the overall design is now being actively pursued. We have divided this area into several phases - an overall functional specification, which will include consideration of the VLA to EVLA transition (the hybrid array), an overall functional architecture and design, and an overall technical architecture and design. Drawing a distinction between the functional and technical aspects is a useful approach that we have borrowed from ALMA.

Realistic estimates of the amount of effort needed to build and verify the EVLA M&C System, including the Observing Layer software, must, of necessity, proceed from the overall design. As the one progresses, so will the other.

Once the M&C group was fully staffed we were able to address the lack of an overall software engineering approach. Our process is similar to the standard model of gathering requirements, creating a design that satisfies the requirements, and proceeding to implementation. However, we are not using the classic "waterfall" model. Requirements, design, and implementation are intermixed and iterated. Schedules and deliverables for each iteration are defined.

Since the formal requirements gathering process has fallen well behind the needs of the schedule, the EVLA M&C group mounted its own requirements gathering effort, sufficient to the task of identifying the core requirements needed to proceed with work to support the test antenna. Many of the core requirements for the test antenna will apply to the final system as well.

We have made progress on the perceived lack of an explicit description of interfaces between M&C and e2e. A global description of the areas of overlap between M&C and

e2e now exists, and further details are being worked out in meetings between M&C and e2e representatives.

Data Management

The committee's points, and our responses, are listed below.

a) Much more astronomer involvement.

This has been done by nominating `Project Scientists' in both aips++ and e2e. The individuals (Steve Myers and Dale Frail, respectively) are very active in their interactions with the programming groups. In addition, in the reorganization of the AIPS++ and e2e management, “sub-system scientists” representing the interests of the EVLA will be working directly with the AIPS++ and e2e programmers.

b) Clear definition of deliverables.

The EVLA Project has prepared four specific software requirement documents to define the required goals of theproject. These are:

- On-Line scientific requirements
- Post-Processing scientific requirements
- Engineering software requirements
- Operations software requirements

These individual documents will be completed in June, after which the Project will define specific milestones to be met by the software groups.

c) Milestones, to be taken seriously.

These will be set up as soon as the requirements documents are finished. The EVLA Project has a software coordinator (Gustaaf van Moorsel) whose function will be to monitor accomplishment of these milestones.

d) Alternate organization models.

A new organizational model, by which the projects will take a lead role in defining the goals and monitoring the results of software development, has been defined by the NRAO Director. We are currently exploring this new empowerment. As there is much commonality between the software deliverable required by ALMA and the EVLA, and the individuals working for both projects, and the e2e and AIPS++ groups are largely within the AOC, we are hopeful that a closer coupling, with more shared effort, can be defined between these projects.

e) Prioritization of development.

This is being done on two levels. On the first, all the software requirements documents are prioritized in a dual-dimension: by time, (i.e., when it is needed), and by importance (i.e., how much it is needed). On the second level, it is clear that some e2e components (such as the dynamic scheduling) could be deferred without major impact on the project. If this were done, we would schedule the array as it has been done in the past. Not optimal, but doable.
It is not yet necessary to consider this second level of deferral.

f) Measure of completion of aips++.

It's true that the aips++ project cannot be considered a success until it is freely and widely used by astronomers. To head towards that goal, we have an active user group (the NAUG) which meets regularly in the AOC to help set priorities for the programmers. The new Project Scientist is very active in working with the programmers to help ensure a product which astronomers will want to use.

EVLA Phase II Proposal

We are pleased to have the Committee's solid support for this final phase of the EVLA Project.

We have expended considerable resources to prepare a detailed and complete Phase II Proposal, which will be ready for submission to the NSF as early as this summer, following final AUI board approval.

It has not proven to be feasible to advance one of the small subcomponents of the proposal (either the E-configuration, or the UHF low-frequency system) to be started early using Phase I contingency resources. Both of these components have costed out at levels much higher than originally estimated, and there are not enough funds in contingency to permit an early start.

Concerning the wideband phased array feed suggestion: We have followed the committee's suggestion and looked at this carefully (for example see EVLA Memo 53) , and have concluded that this is not an acceptable means of providing the sensitivity in the band 700 -- 1200 MHz. However, this solution may well prove effective for lower frequencies, and we continue to develop the concept.