

Response to the EVLA Advisory Committee Report on the Meeting of 14-15 December, 2004

4 April, 2005

The NRAO Director and EVLA Project Team wish 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. This document provides the response of the EVLA Project Team to the Committee's comments and recommendations.

1. Management Issues

1.1 Schedule Issues

The Project is continuing to do everything possible to hold the recovery schedule. In the last three months some delays have occurred due to the need to redesign two circuit boards in the Digital Transmission System (DTS) Module. It is expected that these delays will be recovered when the new DTS module is available in the middle of the year.

The Committee expressed the opinion that the goal of keeping as few antennas out of the VLA as possible, whilst desirable, may be having too large an impact on project staff. The Project is grateful for this advice and will consider relaxing this goal if the impact on on-going observations with the VLA is acceptable. We currently are discussing a significant observing reduction for one quarter during 2006, in the range of 25% to 50%, in order to permit continued software development rather than devoting too many personnel resources to supporting users on the first VLA/EVLA transition system.

1.2 Budget Issues

Concerning the \$4.2 M overrun in planned Contributed Effort from the Operations Budget to the EVLA Project, it has currently been decided by NRAO Management that half of the overrun (\$2.1 M) will be charged to the EVLA Construction Budget. It has further been decided that, as part of this \$2.1 M "payback" to the Operations Budget, during the years 2004-2007, a total of \$1.3 M of AIPS++ personnel costs will be charged to the EVLA Construction Budget.

An additional budgetary concern raised by the Committee is the issue of inadequate resources for the EVLA e2e effort. NRAO agrees with the Committee that provision of adequate e2e tools for less experienced observers is high priority. It has been decided that 10 FTE-years of additional effort (approximately \$1 M) will be provided by the EVLA Construction Budget (see Section 3.1.2 below for more information about this enhanced e2e effort).

When the two new charges described above (\$2.1M and \$1.0M) are included in the EVLA Construction Budget the remaining unallocated contingency is \$2.9M which is approximately 6.5% of the remaining cost to complete the project. This amount of contingency is very low considering the remaining risks in the project and so the risk is high that it will become necessary to implement one of the available hardware descopes.

The Committee suggests that the project also explore the possibility of solving a shortfall in contingency by increasing Contributed Effort levels in the last years of the Project. It is not possible to produce such a plan at present because NRAO does not currently have a multi-year WBS for its Operations Budget. However, NRAO is now working towards having such a multiyear plan and we will return to the Contributed Effort issue when it is available.

1.3 Descope Issues

As noted in Section 1.2 above, the project has decided to apply ~\$1M of its contingency to fund 10 FTE-years of additional work for e2e. This allocation will increase the likelihood of a decision to remove one or more bands from the frequency coverage. From informal discussions amongst our staff, there is unanimity in the view that the first band to be removed would be X-band (8 -- 12 GHz), as the VLA currently has an excellent system which covers a significant fraction of this frequency range. The Committee recommends a careful study of the trade-offs between software development and loss of frequency coverage be made, and notes that dropping two or more bands will create huge holes in frequency coverage. Such a study will be necessary, and will be undertaken, before a decision to remove a second band would be made. We are hopeful that such a decision will not be necessary. If it is, it will not need to be made for some time -- a year from now -- so we are not at this time making plans for such a study.

Before implementing any of the hardware descopes NRAO will discuss the situation with the NSF who are being kept abreast of the EVLA budget situation in the EVLA Six-Monthly Reports.

2. Hardware Issues

2.1 Feed Systems

We agree with the comments of the Committee concerning a likely increase in complexity of polarization observations during the period when there are a mixture of VLA and EVLA feed/receiver systems. We are not currently seriously considering linearly polarized feeds for the EVLA, although from the hardware point of view it would be relatively easy to adopt this course in the future if it looks advantageous.

Concerning the OMT work, the L-Band OMT has been the highest priority of the AOC's most senior microwave engineer. Paul Lilie has recently finished "tweaking" the design (see http://www.aoc.nrao.edu/evla/admin/reviews/feeds/feeds_files/OMT_0502_lilie.pdf)

for results) and is now working towards a series of tests with the OMT cooled. These would also be done with the new 1-2 GHz balanced amplifiers from CDL. As the new L-Band OMT is much too big to fit in the existing VLA L-Band receiver, a new dewar is being designed. We are still some months off from its fabrication. Since the C-Band OMT is a scaled version of the L-Band design, it is likely that the L-Band OMT will undergo a full systems test before the C-Band does.

2.2 Electronic Systems

The Committee points out that it is important to complete necessary design changes and perform adequate testing before starting production of electronic modules. The project staff agree with this philosophy and intend to follow it.

We agree completely that it is important to develop the next generation of radio astronomy instrumentalists and we are already following several of the Committee's suggestions to achieve this. The demanding schedule for the project does not allow time for anything other than the most critical in-house training at present.

Laboratory testing will determine the phase stability, spurious responses, and emissions from individual components in the various systems. These tests will also include the effects of changing temperatures due to module orientation. We can currently simulate two central reference sources and two LO fiber links. It would be easy to add the capability to simulate two antennas worth of electronics (2IF's each). The main limiting factor has been the availability of modules as they have been put into antennas as they are built.

2.3 Correlator

2.3.1 Correlator Hardware

The remarks on liquid cooling are a little out of date at this time. There was no mention of this during the advisory board meeting in Dec/04. Nevertheless, we had at one time thought that this would be necessary. Since then, the expected power dissipation of the correlator chips has been reduced, and we are now very convinced that air-cooling will be sufficient. Large heat-spreaders/heat-sinks will be used on the chip arrays (correlator chips and FIR chips). The heat output per rack is now expected to be well below 10kW per rack. We have built a full-size mock-up of the correlator racks, complete with mock circuit boards loaded with rectifier chips as heat sources. A number of cooling configurations have been tested, and we are settled on a simple design (possibly similar to the rack-as-a-duct configuration referred to in the Report). The design includes speed-controlled fans that can be used to adjust for potential variations in airflow with position in the correlator room.

We fully intend to carry out detailed signal integrity analysis of all boards, including the correlator board. We have purchased software for this task. The realization of the FIR

chips as FPGA's is made possible by the introduction of the Xilinx Virtex IV series (i.e. We have been "saved" by technology).

The VSI interface is the implementation of the VLBI-ready aspect of the original specifications of the correlator. HIA is providing the design and implementation of external circuitry for the VSI FPGA, but will not be doing a detailed FPGA design.

Flexible placement of bands is made possible by a digital mixer that is already part of the FIR design. The FIR design is very advanced. We now have good power dissipation estimates ($<6.5W$), the design synthesizes at speed, and it fits on a moderate-sized Virtex IV chip. There are fall-back positions to take as well (minor descopes of the design) if any of these assumptions prove to be incorrect.

2.3.2 Correlator Software

Memo 18 has now been discussed by all the relevant people during a 2-day meeting in January. The principles elucidated in the Memo 18 have been accepted with minor modifications.

With regard to an us-versus-them mentality developing, we have seen no sign of that occurring yet. The two NRAO employees (soon to be three) working on correlator software are well integrated into the group, although pressure on at least one of them to carry out other tasks must be watched. Nevertheless, the correlator group does have a schedule to keep. Within the boundaries of the Virtual Correlator Interface (VCI) the group will have to make decisions to avoid stalling. Sometimes we will have to make decisions on certain things (e.g. error handling) before this happens on the other side of the VCI. But these decisions are never made in isolation.

2.3.3 Correlator Schedule

Some schedule slippage is acknowledged. Much of this is related to issues arising from correlator chip fabrication. These issues have now been resolved – vendor selection is complete, and the CDR has been held. The vendor is now interacting with the correlator staff on detailed design.

Modelling tools for the FIR chip have been available in "beta" form for several months. We have been using them from the beginning so as to "get a jump" on the schedule. Recently the tools have been released in official form, and our results have not changed. Moreover, rudimentary tests of parts of the FIR design have been done by Xilinx on a physical test chip, using internally generated test-vector stimulation. This was done to check power dissipation, and to ensure that stages 1 and 2, the largest and most complex FIR stages, actually function at speed.

Since we are now convinced that the FIR chip does not require an ASIC implementation, we will not need to hold a CDR in February. A CDR accompanies a decision to commit funds for a detailed design that must be fixed in advance. Because of the inherent ability

to “field-correct” FPGA designs after prototypes have been produced, we do not plan CDR’s for FPGA’s. However, because the FIR is an extremely complex FPGA design, we will develop and review an extensive “test bench”, but it will not be as extensive as would be required for an ASIC.

We agree that there is considerable uncertainty in prototype testing time scales. Nothing can be done about this. We have designed the correlator circuitry with many self-test capabilities. We have purchased a new high-speed logic analyzer and have a 2-Gs/s digital storage scope as well as an X-ray inspection machine and a BGA rework station. We also have a reasonable complement of test equipment for stimulating and testing the prototypes. If our previous experience in this field is a good guide, we are well enough equipped.

Procurement is a major issue. EVLA correlator project-management spends a great deal of time tracking this part of the project. A major mitigating step is planned. We will contract the fabrication of all the circuit boards to a single supplier. This contract is now in the RFP stage. The RFP calls for “turn-key” fabrication in which the supplier sources most components. This approach will streamline the procurement process considerably.

2.3.4 Correlator Cost

Exchange rates, as suggested in the report, are a major concern. So far, the gamble has played out favorably. Inflation is less of a concern at present, because the general decrease with time of the cost/performance ratio tends to offset inflation.

Modifications to the delay module will be done if and when there is time and motivation to do so, but not before prototype testing is complete. The motivation is cost only, and we will try to ensure a smooth fit with the task schedule.

With the usual warnings about exchange rates, etc., the project can afford the increased cost of the correlator chip.

In general we have planned for some cost overruns by allocating a contingency. But, as pointed out in the Report, the allocation is slim. We simply have to work with this.

3. Software Issues

3.1. Monitor & Control and e2e

3.1.1 Design Issues

The Committee rightfully points out a lack of progress on the overall design, in the areas of both Monitor & Control (M&C) and e2e. We intend to address the issues raised by the Committee in this area, and have taken a number of steps to remedy this situation. We agree with the Committee that a mismatch in timeline between M&C and e2e puts

particular pressure on us to define the interfaces between the two systems as early as possible. We see this is one of the major tasks facing the High Level Architecture team (see below), which in this particular area will have to work closely with those responsible for further developing the M&C subsystem design.

3.1.1.1 Monitor and Control

As far as M&C is concerned, we agree that the overall system design as presented in June 2004 contains little detail. Subsystem design for M&C has progressed in the meantime, however, and we intend to give both documentation of the work already done and further development of the design highest priority after concluding phase I of the transition plan in April, 2005. An M&C design document that captures the work already done, and that will serve as the basis for the documentation of additional work has been started. It will address such issues as a multi-level hierarchy for the control implementation and quality control feedback mechanisms. Interface definitions will be contained in or referenced by this document. Finishing this initial design document will be our highest priority following the conclusion of Phase I of the transition plan, and we expect to have it available in June, 2005. Moreover, a report characterizing the information that must be distributed within the M&C system, including an estimate of monitor data (but not visibility data) bandwidth was made publicly available in early March 2005.

The Advisory Committee has correctly identified a lack in the EVLA M&C policies and documentation. While the correct manner of building a MIB module is implicit in the MIB Framework software and documented in the MIB Framework Software Interface Control Document, guidelines for building other system components have not yet been specified. We have not yet adopted coding standards. We intend to address this issue shortly; a likely outcome is that we will adopt ALMA coding standards for any new software.

We point out, however, that the EVLA Computing Division has used CVS for source and version control since the earliest days of module interface board code development. Early in 2004 we deployed Maven, a build environment which also provides a web site deployment tool. Nightly builds, via Maven, have been a standard practice for the last year. It is true that currently an integration and test plan does not exist. We have felt that this particular task is lower priority than others which we have worked on in the past year. The current focus of the EVLA M&C Group is to move its design effort from a bottom-up approach to the level of detailed subsystem design that spans the entire M&C system and includes a specification of interfaces to e2e elements. We acknowledge the importance of a separate integration and test plan, and the formulation of such a plan will be part of the next version of our development plan.

3.1.1.2 e2e

We are aware that the current high-level design is not sufficiently well developed to allow detailed design of the subsystems. Lack of manpower and the priority of completing phase I of the transition plan have prevented us from making enough progress

in this area. Now that phase I is drawing to a close we are in the process of forming a High Level Architecture (HLA) team to arrive at a design with the required level of detail; we expect this team to start in April, 2005. It will also be charged with making the fundamental technology choices (communications technology, utilities) for the e2e effort, which as the Committee rightfully points out have not all been made yet. We note, however, that the Committee may not have been provided with a complete enough set of software documentation in this area, some of which describes in more detail our current level of design. It is impossible to provide every piece of documentation, lest the Committee be buried in paper, and we perhaps erred on the side of providing too little. We will take this as a lesson not to be repeated.

We are committed to ALMA software reuse wherever it is more efficient to do so than to develop software on our own. Our June 2004 overall design is in agreement with the NRAO-wide models as developed in collaboration with the e2e oversight Committee; in addition, we have been working with ALMA to develop a common Science Data Model and Project Model. Other design elements, such as communications technology and scripting language, will be the responsibility of the High Level Architecture team; choices ALMA has made in these areas will be carefully considered. The Committee correctly points out that the EVLA project does not even have the resources to sufficiently investigate parallel developments at ALMA, let alone capitalize on them. We intend to continue to make a convincing case for adding the necessary staff resources (see below).

3.1.2 Monitor & Control and e2e Resources

In his report to the 2005 NRAO Visiting Committee the NRAO Director stated that “two long-term challenges which the NRAO must plan more clearly and address are (1) providing the core software needed to exploit the new capabilities of the EVLA and ALMA and (2) attracting new users from the entire astronomical community, not just black-belt radio astronomers”. The EVLA plan for providing e2e software is a key requirement for meeting these challenges and the Project is committed to work within NRAO’s overall e2e plan to provided the necessary capabilities.

As reported at the meeting, we agree wholeheartedly with the conclusion of the Committee that we are understaffed in the e2e software area. In fact, as noted at the committee meeting, we feel that if no new manpower is assigned to the e2e effort we will likely end up with a software system that is very similar to that of the current VLA. Specifically, not even all of the priority 1 requirements will be met with such an effort. While we agree with the Committee recommendation to make a re-prioritization to define some minimally acceptable subset of current priority 1 requirements (and in fact this effort has begun - see below), we note that with only a subset of priority 1 requirements the EVLA will not have a fully functioning, integrated e2e software system. It is only through the addition of manpower that we can hope to achieve the goal of an integrated dataflow software system for the EVLA.

We recognize that making manpower estimates in the absence of a more detailed design results in an answer with somewhat higher uncertainty. However, we have made a

number of very detailed estimates based on the requirements, comparisons with old Data Management values, ALMA values, and best industry practices, and always come up with a number of the order of 6 FTEs per year, assuming ALMA software re-use wherever appropriate. The fact that these various independent estimates come up with the same answer gives us some confidence in their validity. We are encouraged that the Committee arrived at a very similar estimate, and note that the Committee admits that this is the minimum amount of effort needed. Indeed, if we take the new ALMA numbers (from the re-baselining effort) at face value, we should increase the Committee estimate, which is fundamentally based on the ALMA experience as outlined in the report (the new ALMA number is 280 FTE-years total for computing, of which we might expect something like 2/3 to be e2e-related effort, to put it in perspective).

We are of the opinion that whereas the e2e effort is understaffed, the M&C effort is staffed adequately. We are therefore loath to solve the problem by rebalancing our current staffing, since we feel this would jeopardize the M&C effort. Given this viewpoint, and current manpower allocation for e2e effort, getting to 6 FTEs per year would require hiring at least 4 new software developers. We have made this our goal in terms of new programming manpower. The EVLA project has approved the use of contingency funds for two of these positions and is now working with the managers of the NRAO operations budget to develop a plan in which the additional resources required for e2e programming will be phased in to the operations budget during the next few years.

With an additional 4 programmers, we feel that we can achieve a reasonable dataflow software system. It will still not meet all of the requirements laid out in the requirements documents, but it will meet all of the priority 1 and some large fraction of priority 2 requirements. For example, with this staffing level, we can hope to have at least minimal data reduction pipelines, whereas less staff would probably preclude the development of any pipelines during EVLA construction, deferring them to the operations phase of the instrument. Another example is support of the archive, which without this additional staffing will be minimal at the end of construction. A further example is observation preparation, which without this additional manpower will potentially be limited to standard observing modes at the end of construction. And finally, documentation and ease of use will be considerably improved with this level of staffing. In addition, with this additional staffing we can hope to have a fruitful collaboration with ALMA. In fact, discussions in this vein have already begun, and ALMA and EVLA have agreed to each contribute some effort to arriving at common software models – at least the Project, and Science Data Models. This is a key milestone in the journey towards software collaboration between the two projects.

In addition to the new programmers, new scientific staff effort is required, in order to provide feedback to the programmers (through formal and informal testing, requirements updates, providing use cases, etc...). We have requested the assignment of the equivalent of the full effort from 2 scientific staff members to EVLA e2e software, on top of what is already being contributed via the Project Scientist, Project Scientist for Software, post-

processing, and various EVLA Computing Division members. We are confident that this effort can be located (whether by new hires or reassignments), and productively used.

3.2. Post-processing

3.2.1 EVLA Requirements

There are two key activities underway to accommodate the EVLA requirements planning. The first is the generation of a master post-processing requirements list, which covers both the ALMA and EVLA projects. This provides the detailed information concerning which EVLA requirements are not covered by the existing plan (currently based on the ALMA Priority 1 requirements); the magnitude of effort necessary to complete these items can then be estimated and resources assigned. The second area has been in project discussions to identify use cases which highlight the science that is distinct about the EVLA. An initial use case has been developed detailing the wide-band, wide-field imaging which will be a standard observing mode at the EVLA. The existing development plan has already been modified, following an impact study review and acceptance by the ISD heads (particularly ALMA in this case), and resources have been allocated to work in this area. A short range (one year) plan with milestones has been drafted with EVLA project testing providing the validation.

The internal and external tests sponsored by the project provide ongoing audits of the requirements. However, individual project validation is required for areas in which there are differences in the criteria for acceptance between projects (e.g., different standards for compliance). We intend to identify these areas over the next year, and develop a plan for how to deal with them within the structure of the ISD.

3.2.2 Post-processing Resources

A coarse assessment of the key applications needed by the EVLA which are not common to ALMA was done by the Project (Butler, Perley, and Owen). We are in the process of completing the requirement analysis and audit above which will provide the full measure of the resources needed. The ISD maintains parity between the projects and is the ultimate arbiter between resource and priority conflicts; a report will be provided to the ISD management (Glendenning and van Moorsel) for use in planning and allocations.

3.2.3 Testing

We agree that the number of available testers for EVLA testing is a potential problem. Taking advantage of testers outside of the NRAO is therefore important. For this reason, the number of external testers for the ALMA tests has been increased (eight external testers will be used for the third ALMA test). These new external testers allow us to strike a balance between experienced and first-time testers, providing a wide breadth in feedback and satisfying our need to have both new impressions and a historical perspective on the evolution of the package. The EVLA testing will follow this example, expanding in the future to include external testers. In addition, the parallel EVLA

testing effort will employ a different set of testers from ALMA (those qualified to evaluate the EVLA science case under review) and so will expand the total number of AIPS++ testers. The substantial work required in testing and their timing however limit the pool of testers and the number that can be well supported while maintaining the ongoing (brisk) development schedule.

3.2.4 User Interface

As the Committee stated, the emphasis in development thus far has necessarily been on functionality and stability. However, the interface development has been underway in recent months. A quick summary: The AIPS++ user interface is based on distributed objects/tools which, plainly stated, has been a failure as a user interface paradigm. In addition, the AIPS++ interface is intimately bound to Glish (a scripting language with no other users) and so the ongoing work to migrate to a new Framework is bound to the user interface issue. Our strategy is to adopt the usual task model used in other data reduction packages (AIPS, Miriad, etc). We are in the process of modifying our code to create extremely clean (adaptable) interfaces to tasks; this enables no interruption in the ongoing development of applications in the underlying libraries. Our initial work uses ALMA technology and development resources for prototyping; our initial target is a unix shell command line interface (similar to Miriad). The next step will be to provide an interface through Python. There is an ongoing effort at the observatory (ParselTongue framework) which we may be able to capitalize on; this will be confirmed in the coming few months. Each of these avenues will enable us to iteratively work with scientists on the interface as early as possible (potentially this year).

As requested, we intend to present the status on the interface development at the next year's meeting. This will already have been reviewed internally and so those results should also be available.

3.3. Miscellaneous

3.3.1 Module Interface Boards (MIBs)

We are aware of the dangers of using UDP in the communications layer, including the risk of dropped packets. All aspects of the design have been and will continue to be examined for tolerance of dropped packets. Certain changes in the software design are already planned in order to better address this issue.

3.3.2 Prioritized Requirements

We agree that a renewed assessment of our software requirements is in order, and have begun a complete re-prioritization of our admittedly ambitious scientific requirements. If done well, though, this is a very time-consuming effort, requiring scientific staff effort which is in short supply.

4. Phase II

We are pleased to receive continued strong support from the EVLA Advisory Committee for construction of Phase II of the project. We will continue to encourage the NSF to complete its review process in a timely manner, and to encourage our colleagues to support the completion of the EVLA in every way that they can. As the Committee knows, NSF budgets are very tight, while pressures on the NSF for other instrumental development is very strong. The next step in the proposal review process, a face-to-face reverse site visit at the NSF, is scheduled for mid-June, 2005.