REPORT OF THE 2007 NRAO EVLA ADVISORY PANEL
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CHARGE

The Panel was charged by the NRAO Director to assess the:

- Overall progress in the EVLA construction project, in terms of schedule, budget and scope, with emphases on
  - M/C software development & deliverable
  - Hardware and software for the WIDAR correlator
- Planning for the science commissioning of EVLA
- Status in planning for the integrated (One Observatory) science operations of EVLA and the status of e2e operations

In addition, a number of specific areas were provided for the Panel to focus on and these are addressed in the Report.

The Report is organized into the following major sections:

1. INTRODUCTION

The 2007 EVLA Advisory Panel meeting was held in Socorro during September 6-7 and was attended by thirteen Panel members. Just prior to the meeting, NRAO provided access to either final or mature drafts of the material to be presented at the review.

The Panel would like to thank the NRAO Director, EVLA Project Scientist, Project Manager and the staff for their efforts in preparing and presenting material, and for being so helpful and forthcoming in our discussions during the meeting.

Response to 2006 ELVA Advisory Panel Report

NRAO was responsive to the 2006 Panel recommendations and we commend the team for the seriousness with which they responded.

2. MANAGEMENT

The Panel was impressed with the overall progress of the EVLA project and in particular the progress with the antenna outfitting, Monitoring and Control, and the steps taken by Management to recover schedule. By its nature, the ELVA work overlays the VLA activities and the team has done an outstanding job keeping the VLA operating without loss of efficiency during the EVLA antenna transitions and related tasks.

Excellent progress has been made since last year in developing a set of project metrics for the antenna hardware that includes the EVLA risk register and Earned Value measures. Developing such metrics has become increasingly important to demonstrate NRAO's commitment to modern management practice and the ELVA Project Manager is to be commended for his efforts in establishing a useful set in such a short time. We encourage the team to extend the metrics to the full project schedule and continue to use the tools to track progress, and identify schedule and cost risk for the duration of the project.

Schedule

Detailed schedules are in place for the hardware and monitoring and control software however we have some concern over the progress of the EVLA receivers and correlator and suggest that these be monitored carefully. Now that the project is reaching the final stages of the hardware development it is important to develop a more detailed science driven schedule for the remaining project components required to realize the EVLA science return: the post processing software and the tasks needed to complete the planning and implementation of the commission phase. The schedules for these tasks should be driven by a set of minimum capabilities and then integrated with the hardware schedule (including the correlator development and delivery). We recommend the Project:

(a) Develop a science-driven definition of the minimum capabilities at start of shared risk observations and for first full year.

(b) Develop a more detailed schedule for the post-processing software (CASA/algorithms, e2e) and tasks required for commissioning and the first full year of science operations, including Shared Risk program.

(c) Generate and actively work to a top level Gaant chart of the full project that identifies a critical path and critical dependencies, and integrates the WIDAR development and delivery, the post processing software and tasks required for commissioning and the first year of full science operations.

Progress in the post-processing software, notably CASA, has been excellent in the past year and we recommend **that the software schedule and FTE resource allocation for the remaining development be based on the actual development performance in the past year or so.**

We also recognize that the software development and science commissioning planning is being staffed by software engineers and scientists in a matrix arrangement. Given this, we recommend that **commitments be obtained between the line and matrix manager, and the staff involved to ensure that the work can be completed.**

In the area of the correlator schedule, we believe that the Project will benefit from a closer examination of the Integration portion of the schedule. We feel that with some more detailed planning, it may be possible to realize some schedule recovery. Also, we suggest that an agreement be developed between all parties on the requirement for, and definition of, the critical on-sky tests currently included in the schedule.

Cost

The hardware costs and contingency appear reasonable and are well supported by the risk assessment and register. Good initial progress has been made in developing and defining the software and commissioning plans needed to obtain useful scientific return from the EVLA. However, more detailed scheduling and resource tasking from now through the first year of operations are required to validate the present cost estimates (see above). Based on our experience with similar software and operations planning activities:

The Panel assesses that the present cost estimate for development of the remaining software and implementing the commissioning plans is likely lower than what will be required. Therefore, we strongly urge NRAO (and NSF) to retain at least the present budget level for the EVLA program.

Risk

Based on the progress during the last year, the identified risks, and the budget and reserve posture we assess that the overall technical risk to the EVLA project is relatively low. However we note that the correlator development risks are presently not integrated into the project risk register. Given the critical importantance of the delivery of the WIDAR to the project:

We recommend that the Project include the correlator risks in the overall Program Risk Register.

We recognize that given the international arrangement for this development, it might not be possible to treat the cost risks in an integrated fashion, however there are many technical, integration, interface and schedule risks that need to be included.

Requirements and Test

The EVLA performance requirements have been established for some time and have been made available and discussed with the community. Now that the hardware is being integrated and tested, some requirements may necessarily need to be adjusted due to the actual performance of the hardware. We recognize that in many cases the stated performance requirements are goals and exceed the minimum requirement, however we nevertheless **recommend that if EVLA performance requirements are relaxed, an explicit assessment on the impact to science should be documented and made available to the community. Significant changes should be made in consultation with the community.**

Good progress has been made in identifying the required acceptance/test/verification plans. These plans will be invaluable during the final testing phase of the Project. However, we recognize that there may be some test and Verification and Validation (V&V) plans not yet identified and so recommend that **the Project identify and develop (a) the remaining Test and V&V plans required through construction completion, and (b) the plans required for commissioning and start of science phase.**

3. HARDWARE

Good progress is being made on the hardware development and deployment. The antenna refurbishment and basic hardware installation is going well and seems to be on schedule. Having fiber to all stations available now will simplify the array reconfiguration and commissioning of the EVLA antennas. The electronics production seems to be keeping pace with antenna work. Based on information provided after the meeting the planning and allocation of task resources has been done with enough detail to lead to a credible schedule for the NRAO provided hardware that does not require significant development effort.

The areas of concern to the Panel are the tasks that are pushing the state-of-the-art and still require more development and testing. The risk is mostly in terms of schedule slippage because of unexpected problems that can be encountered in developing new instruments and techniques and the difficulty in having the required expertise to work on the hard problems. The major areas of concern are the correlator schedule and the schedule for completing the implementation of the final EVLA receivers on all antennas. These and other hardware issues are discussed in more detail below in their order of importance.

Correlator

Significant progress has been made on the WIDAR correlator in the last year; the first prototype boards have been tested and revisions made, the power station was installed, correlator chips were fully tested and ordered, great strides for CMIB and GUI software have been made and the first hardware fringes have been produced. Despite this rapid progress WIDAR is still significantly behind schedule and even the success oriented future schedule has serious impact on the testing and commissioning of the EVLA hardware and software. The DRAO group seems to be working hard to push the schedule as much as possible including ordering chips and long lead items as early as feasible, staging the prototype fabrication to get hardware to the EVLA for testing and integration without undue risk of wasting expensive components.

There needs to be a very careful coordination of the correlator lab tests, on the sky tests and integration tasks across the whole project to minimize delays once the various hardware prototype and production components become available. (Note that this is basically a repeat of hardware recommendation #2 from the last report.) It is particularly important to clearly define the NRAO provided hardware and software required for the critical on the sky, basic mapping and long integration tests. Most of the details about the task definitions and schedules were not available to the Panel but the information may be available on the internal DRAO web site and from within NRAO. This information should be made available to the Panel. **The major decision points and options need to be clearly spelled out and agreed upon.**

The practicality of doing the long integration tests in the lab should be investigated. It should be possible to address the false fringes for long integrations in the lab using analog noise sources feeding 4GS/s ADCs or a pseudo random digital noise generator. This would make this critical test independent of the on the sky test at the array site and in a more controlled environment.

Any system with this complexity will encounter unanticipated problems during the end-to-end integration of the components and software. **If feasible, software should be developed to simulate as much of the correlator hardware control input and data output to minimize schedule delays caused by these problems.** This can be a large effort but has proven to be very beneficial in other project with large hardware schedule risk and makes installation and integration of the final hardware much easier to test and debug. Simulation of the data output at even a fairly high level in the data flow is very useful and becomes more useful as it is pushed further down towards the hardware.

The project needs to have contingency plans in place to handle any further delays in the delivery of the correlator prototypes and also for delays in the delivery of the complete WIDAR system.

Calibrating the narrow channels in the high-resolution modes will be a large challenge. The nominal plan made heavy use of the auto-correlations but the recently adopted design change for the crossbar switch means that some of the auto-correlations are not available in some configurations. The system design for the channel calibration needs to be worked out in enough detail to understand the implication of the missing auto-correlations.

Receivers

The EVLA staff has done a good job of using a mix of existing, transition and interim receivers to outfit the refurbished antennas with a nearly complete complement of receivers and keeping them scientifically useful. But there are essentially no final EVLA design receivers on the telescopes (there are three fully EVLA compliant K-band receivers) and the design or successful prototypes of some critical components, such as the OMTs, are not complete for some bands. The loss of critical RF engineers for the OMTs has greatly slowed this development but progress is being made using other engineers at NRAO.

The OMT development is still on the critical path and this development effort needs to be closely monitored.

The current receiver development has met or exceeded the performance goals in most bands so the risk of not meeting the major performance goals is small although there remaining design and development tasks present a large schedule risk. Also the number of complete EVLA receivers that need to be built, tested and calibrated is very large, essentially the full complement of receivers. **It is recommended that a plan be worked out that implements the set of the scientifically most useful receivers in their final EVLA configuration on all antennas and delay the implementation of the less productive receivers if necessary.**

Digitizer

The final 4GS/s digitizer chips are not yet available and this represents a significant risk both for the delivery of the commercial chips and for testing and debugging of the final digitizer boards. **The delivery of the 4GS/s digitizer chips should be carried as risk items with mitigation options.** Issues of cross-talk, self generated EMI and temperature dependent delays still need to be evaluated using the final chip and board design. **The plan for adding the new ADC boards should receive very careful scrutiny.** It might even be worth mounting one of the existing test boards (with the present generation 4-bit ADC) inside the sampler module in order to perform tests of EMI and, with the module placed in an environmental chamber, the thermal stability.

Maintenance and Repair Tracking

The Panel was surprised to learn that the existing VLA maintenance and repair tracking system has not already been implemented for the EVLA modules. The **Project should implement a repair and maintenance tracking system soon to avoid wasted effort and confusion while commissioning the EVLA.**

4. SOFTWARE

We are very pleased overall to see excellent progress in the software development area and commend NRAO for the strong steps that have been taken to improve in this arena. The M&C software development appears to be on track with no apparent show-stoppers. Significant progress has been made establishing the EOD and developing collaboration across EOD and the EVLA project, with improved communication between the EOD lead and the EVLA software project leads. The Panel was also favorably impressed by

the CASA development demonstration. Many basic tools and tasks are clearly already present in the current CASA, with many fundamental AIPS-replacement tasks expected in the near future. It is also clear that more attention is being paid to the twin issues of algorithm development and compute capability.

We provide observations and recommendations in the following areas that we feel are important to focus on in moving forward.

Software Schedule

It is important that a robust software development schedule with clear milestones be developed and integrated into the overall project schedule so that progress of the software can be tracked and monitored. Such a schedule needs to clearly indicate and include CASA and EOD development contributions. We were encouraged to see the use of schedules to track progress to date for EOD development, however note that there is not yet a clear transition shown from the prototype development to the required fully tested operational software. See Section 2, Schedule.

Software Reuse and Commonality

Given the strong start that EOD has made, we believe that the time is ripe to finalize plans for common and reuse software with ALMA. The project has made some good initial steps towards reuse (e.g., schedule blocking and data models) however further work is needed to define the extent of the commonality and reuse, e.g., degree of common look and feel, extent of reuse of a common underlying software architecture. Difficulty with catching up with projects not started jointly (like ObsPrep and Scheduling) is clear and shown by the slow progress in these areas. We urge the project to take a proactive approach in working with the ALMA team to define the reuse and commonality. EOD should also prioritize the work in this area and not attempt to meet every request, i.e., aim to deliver the minimum needed to meet the needs of both projects. Once identified, the software plans and delivery milestones should be incorporated into the Project schedule and the responsibilities for development and delivery agreed to.

We recommend that the plans for common software and reuse with ALMA be finalized as soon as possible.

CASA

As noted above, CASA has recently taken strong steps forward towards becoming a useful software package for radio astronomers. CASA is well on the road to becoming a successful collaborative software model for ALMA and the EVLA, however it is absolutely vital that success not be declared too soon.

The minimum CASA capability needed for commissioning and the shared risk science phase must be defined as soon as possible, and a clear schedule and plan for achieving those capabilities be put in place. We also caution against developing generic capabilities

but rather encourage the Project to focus on producing capabilities that are linked directly to the needs of the specific scientific use cases for the EVLA.

The progress and momentum that has resulted in the good progress for CASA is the result of an outstanding combined team of software developers and scientists. **Great care should be taken in making changes to the CASA team staffing. If changes are required, careful transition planning is of great importance. Continued strong leadership for CASA is vital.**

Algorithm Development

Algorithm development is linked closely to the scientific productivity of the EVLA and we are concerned that there is not yet clear agreement on the algorithm development requirements for the EVLA or a plan for what algorithms are needed at the various stages of the Project. As a first step it is important that a firmer scientific basis be developed for understanding the algorithmic development needs for the various scientific modes of the EVLA. The Panel heard a variety of opinions on this topic from different NRAO scientists.

While it is clear that NRAO has taken seriously the need to better coordinate algorithm development efforts across projects and to marshal its existing resources towards this goal, it is also not yet evident that a path to success is in place. We note that deep algorithmic problems are not typically solved by *n* people working for 10-20% of their time and that this has implications on the staff assignments in this area. We also feel the Project will benefit from a clear leader for algorithm development.

We recommend that the Project take a deeper look at its resources and plans for algorithm development and assign a clear lead for this area.

We see engaging the community in algorithm definition and development as an opportunity that NRAO should use to full advantage. **We recommend that plans for engaging the community in algorithm definition and development be better defined. In cases where NRAO is relying on the community for algorithmic development, consider establishing cooperative agreements or active collaborations to ensure the delivery.**

Computer Hardware

The computing performance requirements for the EVLA post-processing software will be driven by the final selection of algorithms. Since the algorithm definitions have not yet been converged, it is perhaps not surprising that the computing performance requirements and hardware are not yet defined. For example, it was not clear yet if a brute-force approach will be possible (or needed), or how parallel computing may figure in the final solution, or if there was in fact likely to be a compute problem or not. The time is ripe for this to be addressed and we recommend that **NRAO develop a clear scientifically based**

set of performance requirements for compute power that is integrated with the software and algorithm development plans, and operational requirements.

Staffing Level

As discussed in Section 2 under Cost, we are not able to fully assess the staffing level for software development without an integrated, resource-loaded development schedule. We are however concerned that the current staffing may be lean, based on our experience with projects of similar scales. We recognize that factors such as the degree of reuse and commonality with ALMA software, and the allocation of EOD staff and deliverables will impact the final staffing and encourage NRAO to maximize these overlaps.

5. COMMISSIONING AND OPERATIONS

The plans presented for the scientific commissioning and transition to operations for the EVLA were appropriate for this stage of the project. Top-level plans are in place for the verification of data from the antennas and the validation of the antenna, receiver and system performance against the EVLA Project Book requirements. Plans for scientific commissioning are also in place at the top-level and will begin with on-sky testing of the corellator prototype in late 2008 in parallel with the integration phase. The basic science modes will be commissioned in 2009 leading to the start of the shared risk science phase, following by the special science modes in late 2009 and 2010. We concur with the plans at the level presented and recommend that the next step of detailed planning for these key tasks be conducted and incorporated into the overall project schedule and resource loading. **We recommend that a detailed science driven task schedule with staff assignments be developed from the start of correlator on-sky testing (October 2008) to the end of the first year of science operations. This Schedule should be included in the program schedule** (see first recommendation under Schedule, item c).

The commissioning phase is likely to draw heavily on observatory science resources and may affect NRAO's ability to maintain the usual level of community support for the VLA. In planning for the commissioning, we recommend that **NRAO consider the impact of commissioning on science operations and adjust resources as needed; this may include reducing support to the community for a limited period.**

The shared risk program will be an important opportunity to utilize community expertise to shake out the EVLA end-to-end system and gain community support for the telescope. We believe that the program will be most beneficial if visitors commit to participate for an extended period (months), and are able to spend time at the site working directly with NRAO staff. We suggest that these or similar ideas aimed at maximizing the engagement of the observer be incorporated into the call for shared-risk programs.

As the planning for commissioning and transition to science operations has progressed it is becoming clearer that there are a number of important science policy decisions that will need to be made in order to maximize the science from the EVLA. The question of

correlator resource allocation is a good example where policy must determine how the data and data rights are allocated. **We recommend that the Director and EVLA management identify and develop those policies needed for the start of the shared risk science phase. The policies should be developed in consultation with the SAGE committee, and be developed in time to support the call for the shared risk program.**

The Panel noted the preliminary thinking given to the idea of an "Integrated Science Center" and recognizes that the details remain to be developed. Since we were not provided with sufficient detail at this review to provide an assessment, we suggest that the topic be revisited at the next review.

APPENDIX: SUMMARY OF RECOMMENDATIONS

The major recommendations from the report are summarized below.

Management

1. Regarding schedule, we recommend that the Project:
    a. Develop a science-driven definition of the minimum capabilities at start of shared risk observations and for first full year.
    b. Develop a more detailed schedule for the post-processing software (CASA/algorithms, e2e) and tasks required for commissioning and the first full year of science operations, including Shared Risk program.
    c. Generate and actively work to a top level Gaant chart of the full project that identifies a critical path and critical dependencies, and integrates the WIDAR development and delivery, the post processing software and tasks required for commissioning and the first year of full science operations.
2. The software schedule and FTE resource allocation for the remaining development should be based on the actual development performance in the past year or so.
3. For the remaining post-processing software development and commissioning planning, commitments should be obtained between the line and matrix manager, and the staff involved to ensure that the work can be completed.
4. The Panel assesses that the present cost estimate for development of the remaining software and implementing the commissioning plans is likely lower than what will be required. Therefore, we strongly urge NRAO (and NSF) to retain at least the present budget level for the EVLA program.
5. The Project should include the correlator risks in the overall Program Risk Register.
6. If EVLA performance requirements are relaxed, an explicit assessment on the impact to science should be documented and made available to the community. Significant changes should be made in consultation with the community.
7. The Project should identify and develop (a) the remaining Test and V&V plans required through construction completion, and (b) the plans required for commissioning and start of science phase.

Hardware

8. The Project should carefully coordinate the correlator lab tests, on the sky tests and integration tasks across the whole project to minimize delays once the various hardware prototype and production components become available. The major decision points and options need to be clearly spelled out and agreed upon.
9. The practicality of doing the long integration tests in the lab should be investigated.
10. The Project should develop contingency plans to handle any further delays in the delivery of the correlator prototypes and also for delays in the delivery of the complete WIDAR system.

11. Develop a plan that implements the set of the scientifically most useful receivers in their final EVLA configuration on all antennas and delay the implementation of the less productive receivers if necessary.
12. The availability of the 4GS/s digitizer chips should be carried as risk items with mitigation options.
13. The Project should implement a repair and maintenance tracking system soon to avoid wasted effort and confusion while commissioning the EVLA.

Software

14. The plans for common software and reuse with ALMA should be finalized as soon as possible.
15. Great care should be taken in making changes to the CASA team staffing. If changes are required, careful transition planning is of great importance. Continued strong leadership for CASA is vital.
16. The Project should take a deeper look at its resources and plans for algorithm development and assign a clear lead for this area.
17. Plans for engaging the community in algorithm definition and development should be better defined. In cases where NRAO is relying on the community for algorithmic development, consider establishing cooperative agreements or active collaborations to ensure the delivery.
18. Develop a clear scientifically based set of performance requirements for compute power that is integrated with the software and algorithm development plans, and operational requirements.

Commissioning and Operations

19. Develop a detailed science driven task schedule with staff assignments from the start of correlator on-sky testing (October 2008) to the end of the first year of science operations. Schedule should be included in the program schedule.
20. In planning for commissioning, consider the impact of commissioning on science operations and adjust resources as needed; this may include reducing support to the community for a limited period.
21. The Director and EVLA management should identify and develop those policies needed for the start of the shared risk science phase. The policies should be developed in consultation with the SAGE committee, and be developed in time to support the call for the shared risk program.